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# Designing and Implementing a Hospital Environmental Management Framework

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**Designing and Implementing a Hospital Environmental Management Framework**

By

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## ABSTRACT

Modern Canadian hospitals are large generators of landfilled waste. However, much of the waste disposed of by hospitals is divertible. A Hospital Environmental Management Framework (HEMF) was designed and implemented in a local hospital in an effort to control the organization's landfilled waste and improve environmental performance. Environmental issues are gaining awareness among businesses in other sectors, but are not commonly addressed in hospitals, where patient care takes priority over the environment. While specific, recommended waste reduction initiatives tailored to hospital operations have been widely published, information on *how* to implement these initiatives is lacking. The results from this research yielded a significant decrease in landfilled waste, a notable increase in recycled items, and a significant decrease in waste hauling costs, indicating that the HEMF was a success. The proposed HEMF can be implemented by other hospitals to improve their waste management.

# DEDICATION

To my family, whose unwavering support is immeasurably appreciated.

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# CHAPTER 1

# INTRODUCTION

## 1.1 PROBLEM STATEMENT

The primary focus of modern-day hospitals is to maintain the health of the population and aid the sick throughout recovery. While idealizing intentions of good health, hospitals are large institutions, and with size comes significant environmental impacts, such as: emissions to air, land, and water, inefficient energy consumption, lack of recycling, excessive waste generation, and increased traffic and noise levels (Douglas and Meltzer, 2004). Modern Canadian hospitals are large contributors to the landfilled waste stream. Much of the waste disposed of by hospitals is preventable: controlling their landfilled waste would lower their environmental impacts and provide significant benefits.

## 1.2 OBJECTIVES

The main objective of this research is to reduce the waste sent to landfill by modern hospitals. This will be accomplished by developing and implementing a Hospital Environmental Management Framework (HEMF) - a comprehensive approach to improving a healthcare facility's environmental performance, which incorporates elements of an Environmental Management System (EMS) and attempts to harness innovations specific to hospital settings.

According to the Environmental Innovations Branch of Nova Scotia (2004), an EMS is "a set of management procedures that allows an organization to identify, evaluate, and reduce the environmental impact of its activities." A traditional EMS encompasses multi-media impacts of an organization (i.e. land, water, and air impacts). However, this thesis will focus on the hospital's production of waste that would nominally classify as municipal solid waste (MSW). According to the United States Environmental Protection Agency (2013), municipal solid waste consists of everyday items that are discarded after use, including newspapers, product packaging, food scraps, etc.

The research and HEMF implementation will be carried out at a local test hospital which represents the characteristics of most modern-day Canadian hospitals; that is, the hospital is located in a typical urban setting, serves a large, diverse population, and is under budgetary and resource limitations. The test facility is a teaching hospital located in Southwestern Ontario with over 2,000 employees, physicians, and volunteers, and 324 patient beds.

The research has the following sub-objectives to complement the main objective:

1) Determine the composition of baseline landfilled waste generated by the test hospital;
2) Determine which areas of the hospital generate the highest amount of preventable waste, and give these units top priority in waste management efforts;
3) Implement relevant waste management initiatives; and
4) Determine the amount of waste reduction and financial savings achieved by the implemented initiatives.

The objectives of this research will be accomplished not only by developing and implementing an HEMF, but by understanding barriers to hospital waste management, as well as recognizing which actions will compliment the HEMF. A conventional EMS merely dictates the process to follow by which an organization can improve their environmental performance. This HEMF goes beyond the simple EMS process to include step-by-step instructions on how to achieve results. For example, rather than simply stating that waste reduction initiatives must be implemented, this HEMF suggests targeted projects which will achieve this goal, such as blue wrap recycling, reusable pharmaceutical containers, etc. Each step of the proposed HEMF implementation process is supported by hospital implemented suggestions. This research will establish not only best practices, but innovative practices toward achieving improved hospital waste management.

## 1.3 BENEFITS OF INCORPORATING EMS ELEMENTS INTO HEMF

EMS elements will be incorporated into the HEMF, as they have been shown to improve environmental performance in the following ways:

1) **Compliance with an EMS forces an organization to enact its due diligence**

   To comply with an EMS, yearly audits must be performed and environmental impact reporting must be published (European Commission, 2013). By requiring accountability, an EMS ensures that the organization will truly follow the implemented initiatives and waste reduction program. To provide reporting and audit results, data is required. This encourages an organization to track their progress and commit to the program.

2) **An EMS provides a detailed framework for compliance**

   By creating a simple process for complying with the waste reduction initiatives, even the busiest of staff will be able to effectively participate in improving environmental performance.

With no real framework for use, the waste reduction projects may be misused or underutilized. Policies and procedures will be designed and implemented for each initiative encompassed by the HEMF. This will communicate expected compliance, as policies are enforced in the workplace.

**3) An EMS dictates responsibility**

Without proper delegation of responsibility, the waste reduction initiatives will not be successful. Employees are responsible for participating in waste reduction programs, and designated champions will be available to answer any questions that may arise. It is imperative that staff understand the proper use of the new technologies, as well as the environmental importance of the initiatives.

## 1.4 HYPOTHESIS

The test hospital will benefit from the implementation of an HEMF in the following ways:

1) Reduction in solid waste sent to landfill;
2) Reduction of operational costs (removed waste is billed by weight; the less landfilled waste, the lower the cost); and
3) Reduction in negative environmental impact.

Given the complexity of hospital settings, implementation of environmental practices will be more effective if a series of small changes are introduced, rather than a single, mass transformation of operations.

## 1.5 SIGNIFICANCE OF HEMF RESEARCH

Several businesses and other organizations have successfully implemented an EMS to control their environmental performance (Commission for Environmental Cooperation, 2005). However, hospitals present unique obstacles to taking environmental action, which highlights the significance of HEMF research. These barriers must be overcome in order to pave the way for future environmental success. Many hospitals have yet to formally commit to improving their environmental performance. This is due to a number of reasons, including, but not limited to:

1) **Patient health is the main focus for hospital organizations**

   Environmental performance is secondary to the importance of providing quality healthcare. While the status of the environment is important, a hospital's main concern will always be human health. Human health is affected by the health of the environment (Douglas and Meltzer, 2004), and an innovative integrated approach to healthcare and environmental performance will be beneficial.

2) **Lack of expertise/champion**

   No employee position exists at the test hospital to specifically deal with improving environmental performance. Any staff members working towards reducing environmental impact are often doing so on a voluntary basis, typically on top of their stressful and busy workload. While staff may be aware of the facility's landfilled waste issue, there may be a lack of knowledge of evidence-based practices related to environmental management. Healthcare providers are generally not educated in environmental issues, and would not be aware of the methodologies available to control environmental performance.

**3) Resource constraints**

Time and money constraints are major factors in the implementation of any project, both of which are uncommon in a hospital setting. With little time to devote to the design and supervision of a project, as well as a lack of funds required to purchase equipment, environmental programs are not prevalent in hospitals.

**4) Employees are incredibly busy**

Hospital nurses, physicians, support staff, and volunteers are incredibly busy during their workdays. Misconceptions of the difficulty of environmental management may have previously prevented its implementation. It is the goal of this thesis to implement an HEMF that is straightforward and convenient: even the busiest of employees should be able to follow the program.

**5) Belief in direct disposal for contaminated items**

Many materials in a hospital setting come into contact with patients (tongue depressors, scissors, oxygen tubing, etc.). It is widely believed that in order to prevent the spread of disease, used materials should be placed in the garbage for direct disposal to landfill (Branswell, 2012), or incinerated (Lee et al, 2002). Unless the used items came into contact with an extremely infectious agent (in which case, separate disposal procedures exist), these materials can often be recycled or composted without harm. Many reprocessing techniques involve the application of extremely high temperatures (Al-Salem et al, 2009), which would disinfect the contaminated items.

**6) Lack of environmental/situational awareness**

Many employees are unaware of the gravity of the test hospital's landfilled waste situation (Munoz, 2012). While throwing a single empty can into the trash may seem insignificant to them as individuals, the cans disposed add up quickly. If each employee continues their environmentally-taxing behaviour, thinking it has no impact, the situation will spiral out of control. Staff are also likely unaware of the negative financial effects caused by unintentional wasteful behaviours. Until employees understand the reality of their actions, they will be unlikely to change their ways. A comprehensive information strategy and later, employee education program (if necessary), are key elements to bringing about long term change.

**7) System flaws (inertia)**

Hospitals and their employees have treated waste in the same way for many years: it is difficult to alter established habits and approaches. However, there have been major improvements in waste management capabilities and strategies. More items can now be recycled, and composting is emerging as a viable waste diversion measure.

The aforementioned hospital-specific barriers to implementing an HEMF can be addressed in the following ways:

**1) Staff education**

If employees are aware of the gravity of their organization's environmental performance, as well as the potential for success associated with project compliance, they will be more likely to make an effort to change their ways and improve their personal waste diversion rates (Munoz, 2012).

2) **Effective communication and promotion**

Staff should be constantly aware of the "right thing to do" when disposing of their waste. Effective information and communication (newsletter articles, intranet notices, proper signage, etc.) will ensure that employees never have to question how they should dispose of their used items.

3) **Implementation of technology**

By implementing new technologies (such as in-vessel composters or automated bedpan flushers), the test hospital will be able to accomplish waste diversion in a way that would not be possible with current practices.

4) **Leadership engagement**

In order to positively influence the implementation of employee-led initiatives, hospital leaders (supervisors, managers, directors, etc.) must be fully engaged and on board with the new procedures. Staff buy-in can be achieved through successful management practices, and a positive, encouraging work environment is conducive to the acceptance of change (Goretsky, 2003).

## 1.6 MEASURING THE SUCCESS OF THE HEMF

Following implementation of the HEMF and a period of staff adjustment and adaptation, it will be necessary to measure the system's success. The effectiveness of the HEMF can be determined through:

1) **Achieved waste reduction**

A follow-up waste audit will determine the amount of landfilled waste being generated by the test hospital subsequent to HEMF implementation. This can be compared to the baseline waste generation as determined by the initial waste audit, establishing the amount of waste reduction achieved by the HEMF initiatives.

2) **Reduced waste removal costs**

Waste collected for disposal is billed by weight. Therefore, the more waste generated, the more the test hospital must pay for its removal. By sending less waste to landfill, the organization should realize a decrease in the costs for waste removal.

3) **Reduced purchasing costs**

Reducing the amount of resources consumed will lead to a reduction in purchasing costs. For example, as seen in section 3.2.4, if bedpan flushers are installed in patient care departments, fewer soiled bedpans will be sent to landfill to avoid manual cleaning. This will lead to a decrease in the number of replacement bedpans that must be purchased.

## 1.7 TRANSFERABILITY

As stated in section 1.2, an environmental management system is a set of management procedures that allows an organization to identify, evaluate, and reduce the environmental impact of its activities. The very nature of an HEMF (policies and procedures) makes it amenable to transfer to other hospitals. This research can lead to a future policies that outline acceptable environmental practices with the goal of reducing landfilled waste. This framework should be easily transferable to other hospitals which until now did not believe that controlling their landfilled waste in a fast-paced and sometimes uncertain healthcare environment was feasible.

The initiatives and policies should be easily adopted by other hospitals, as they will have already been conceptualized and documented. The only action required to implement these policies and initiatives at other organizations will be customization to the specific facility (if needed), and education of staff on the new guidelines. The HEMF will include a list of projects/initiatives that will improve environmental performance, which can easily be used by other hospitals: it may be as straightforward as choosing which initiatives to implement. At the very least, this research can provide a basic template to guide the implementation of an HEMF in other hospitals.

The HEMF created through this research will focus on waste management, but this framework can be expanded to include water usage, energy consumption, and atmospheric emissions in the future.

# CHAPTER 2

# REVIEW OF LITERATURE

## 2.1 REDUCING HEALTH CARE'S CARBON FOOTPRINT – THE POWER OF NURSING

Munoz (2012) extensively researched the role of healthcare providers in hospital waste management, and her findings are as follows:

Hospitals are among the worst environmental performers. Healthcare facilities are charged with improving human health, yet they contribute significantly to the declining health of the environment. It is estimated that US hospitals generate over 2 million tonnes of waste each year. Healthcare procedures often utilize a multitude of supplies, which are considered contaminated and requiring disposal if they are opened but unused, creating a vast amount of waste.

Paper and cardboard comprise 45%-50% of hospital waste, but is usually discarded to landfill, rather than recycled. Plastics make up another 15%-30% of hospital waste. Unrecovered or incinerated plastic releases carcinogenic dioxins into the environment.

Hospitals operate around the clock, and generate a wide variety of waste types. Incineration leads to the release of toxic chemicals into the atmosphere, while landfilling waste contributes to greenhouse gas emissions and harmful leachate. Due to the several complexities involved in hospital waste generation and disposal, addressing these issues is a difficult task.

Nurses comprise the largest group of hospital employees, and a great amount of healthcare waste is generated at the patient bedside. Environmental activism must be a factor in nursing practice, which should prevent harm by reducing the hospital's carbon footprint. If proper waste management is considered as part of nursing practice, rather than as an additional task, positive changes will be adopted over time.

The majority of hospitals have not made an effort to be more environmentally-friendly. Typically, nurses do not feel that their single contribution to the waste stream could have an effect on the environment. There is often a lack of responsibility for actions, since there are several healthcare providers performing the same activity (putting waste into the trash instead of recycling). There is also often a desire to let someone else take the lead on environmental initiatives, but when nobody does, no action is taken for change. It is important for nurses - and all hospital employees - to see themselves as an integral component of a larger system that benefits them (the environment), not as a stand-alone employee. This mentality is more likely to lead to a positive shift toward sustainable actions.

Further research is needed to document effective strategies to develop environmental policies and promote sustainable practices. Current literature focuses on the negative impacts of uncontrolled hospital waste management, but little information is available on the subject of controlling this waste successfully.

In summary, Munoz (2012) determined that a lack of environmental understanding, coupled with passive behaviours, has led to indifference among healthcare providers toward waste management. While it is well-documented which initiatives can potentially reduce landfilled waste, further research into how to actually successfully implement, maintain, and monitor these initiatives would be beneficial.

## 2.2 ANALYSES OF THE RECYCLING POTENTIAL OF MEDICAL PLASTIC WASTES

Lee et al (2002) studied the plastic waste generated at various hospitals throughout Massachusetts. Their findings are summarized below:

Traditionally, medical waste has been incinerated or sent to landfill. In 1996, the United States Environmental Protection Agency (US EPA) estimated that there were 2300 medical incinerators in use across the country. Historically, medical waste has been improperly treated in incinerators that are either poorly designed or insufficiently controlled. This has led to the emission of hazardous air pollutants (mercury, lead, dioxins, furans, etc.) and to subsequent public concern over the proper disposal of medical waste.

If medical waste is not infectious, it does not require incineration. It can be recycled or sent to landfill. According to the US EPA, plastics accounted for 25.1% of landfill space by volume in 1996. The average recovery rate of all combined recyclable items was 27.3%, while the recovery rate of plastics alone was 5.4%. Plastics occupied a large amount of landfill space, as they were not effectively recycled.

Plastics comprise an average 20%-25% (by weight) of medical waste, which is a significantly higher fraction than the plastics content of regular municipal solid waste. To conserve landfill space, increase plastics recovery, and reduce the high cost of hospital waste disposal, it would be beneficial to focus on plastics recycling in healthcare facilities.

This study evaluated the plastics generation of 3 animal hospitals and 8 general hospitals. The most prevalent plastic items in the hospitals' waste streams were cafeteria plastics, sharps, medical packaging, and IV bags and tubing.  These items comprised 67% of the total hospital plastics.

Approximately 73% of the total studied waste was generated in laboratories, facilities, and operating rooms, but the cost for disposal of these wastes amounted to 83% of the total. This is due to the fact that waste generated in these areas is more likely to be considered hazardous, and therefore is incinerated which is more costly than landfill).

The average plastic content of all the studied waste was 30% by weight. Plastics generated in operating rooms, labs, etc. are often incinerated due to their potential contamination, but plastics generated in the cafeteria, offices, and other hospital areas are prime candidates for recycling.

The main barrier to the development of medical plastics recycling programs is the potential contamination of plastic items. The overly-broad classification of hazardous waste prevents some otherwise recyclable items from being recovered (they are incinerated instead). Since the cost of hazardous waste disposal continues to rise, and landfill availability is decreasing, many hospitals have made an effort to minimize their waste generation and increase plastics recovery.

Non-contaminated cardboard, paper, glass, and metal are being recycled in several hospitals. The recovery of plastics is increasing, and the new focus is on recycling IV bags. Only 10% of IV bags are contaminated during use, but the majority are disposed of in the hazardous waste stream, due to lack of information. This leads to a significant increase in hazardous waste disposal costs.

If items cannot be recovered (hazardous waste), it would be beneficial to switch to less toxic materials. If recycling is not an option, it would be an improvement if fewer contaminants were released during the incineration process.

In summary, Lee et al (2002) determined that proper waste classification and segregation can lead to an increase in recycled plastics. If plastics cannot be recovered for contamination purposes, it is recommended that less toxic base materials be used to manufacture these items, which will reduce the toxins emitted upon incineration.

## 2.3 HOSPITALS THAT GO GREEN CAN SEE GREEN WITH EFFECTIVE WASTE STRATEGIES

Gillmeister (2012) reports on the waste management situation among American hospitals. Her findings are as follows:

In the United States, the healthcare sector's environmental footprint is growing (8% of the country's total footprint). US hospitals are the nation's largest contributors of carbon emissions, and the second-largest energy consumers. Together, US hospitals generate 6,600 tonnes of waste daily. Traces of medications can be found in drinking water, and syringes and other infectious wastes are making their way to landfills, illustrating deficiencies in hospital waste handling.

Clearly, improvements to how hospitals handle wastes are needed, but this is not an easy task. Hospital waste streams are complex, approximately 80% of which are highly regulated. Internally, no single hospital department is in control of all aspects of waste collection.

The first step towards effecting change in waste management is to perform a waste audit to determine which waste streams require immediate attention. It would be beneficial to observe current practices in all areas of the hospital to establish what areas require improvement.

There are six considerations for the strategic management of hospital waste, including:

1) Anticipate barriers and complications when implementing a coordinated waste management effort;
2) Understand that waste amounts will vary (facility size, local regulations, and patient volume all contribute to waste generation);
3) Consider partnering with a licensed third-party waste management company to ensure compliance;
4) Opt for sustainable practices whenever possible (for example, utilize reusable containers instead of a disposable option);
5) Keep track of waste costs, both direct and indirect; and
6) Develop a “Green Team” comprised of hospital staff to create change throughout the organization. Executive support is recommended to lend credence to the project.

Even though waste is such a large component of hospital operations, 90% of hospital leaders surveyed had no idea how much waste removal was costing their facility. It is important to track costs in order to understand the impacts of proper waste management.

In summary, Gillmeister (2012) determined that while hospitals generate a large amount of complex waste, proper segregation and waste management practices can lead to cost savings, which benefits both the hospital and the environment.

## 2.4 HOSPITAL WASTE MANAGEMENT AND TOXICITY EVALUATION: A CASE STUDY

Tsakona et al (2007) studied hospital waste management practices. Their findings are summarized below:

Little attention is given to the management and disposal of hospital waste. Current waste management practices differ among hospitals, but the associated difficulties are nearly identical. The segregation, collection, packaging, storage, transport, treatment, and disposal of waste all present challenge to healthcare facilities.

A study of the hospital identified the following problematic waste management practices:

- Municipal solid waste was often discarded in the hazardous waste stream. This unnecessarily increased the amount of hazardous waste to be incinerated, and therefore lead to higher costs.
- Poor-quality (thin) garbage bags were used. Bags had to be removed before they were full in order to prevent tearing, which leads to an excess use of bags.
- There was insufficient labeling of waste streams. This creates confusion while discarding waste.
- Hazardous waste was handled manually, which can lead to a needle-stick injury or infection to waste personnel.

- Hazardous waste was transported in the same cart as municipal solid waste, creating the opportunity for the municipal solid waste to become contaminated before going to landfill.
- Waste collection carts were not properly disinfected, which could lead to the transmission of infection.
- Waste collection carts were overfilled, which could potentially lead to a spill.
- Waste personnel wore only thin gloves while collecting waste, which is not sufficient to protect against needle-stick injuries.
- There was no designated elevator for waste. Healthcare providers and patients used the same elevator as waste handling personnel, which can lead to cross-contamination.
- Hazardous waste was not stored in an area inaccessible to the public – anyone could access the area, which could lead to transmission of infection.
- Waste was stored at times for greater than 24 hours. This could lead to unsafe conditions.
- The waste storage areas were not properly cleaned upon waste removal. Liquid stagnated on the floors and was not removed.

In order to overcome the aforementioned waste management issues, it is recommended that:

- Proper training must be provided to all hospital employees. Anyone who generates, disposes, packages, or transports waste must know how to do so properly. Staff must also be made aware of the potential consequences associated with improper waste management.
- Discipline must be enacted if employees are found to be non-compliant with proper

waste management procedures.

- Effective waste bags and containers must be utilized, and each waste receptacle must be properly labeled.
- Waste carts are required to be easy to clean, and it is recommended that each hospital area has their own waste cart, to prevent cross-contamination among units.
- Waste must be stored in areas that are only accessible by waste handling personnel and their supervisors.
- Waste collection should reflect the frequency of waste generation. Waste should not be stored for over 24 hours.
- It is recommended that a recycling program be set in place to recover as many items as possible.
- Waste handling staff must be equipped with proper personal protective equipment (puncture-resistant gloves, eye protection, etc.) to prevent infection.

In summary, Tsakona et al (2007) observed a wide array of unfit waste management practices and provided several suggestions to remedy the situation. Hospital waste is not dealt with appropriately; however, there are readily-available solutions to resolve these issues.

## 2.5 THE ENVIRONMENTAL TOLL OF PLASTICS

Environmental Health News (2009) reports the following:

Plastic has become a staple in modern society. A strong material, plastic has the ability to remain in use for a number of years, yet today's main use of plastic is for disposable goods, which end up in landfills and will persist for centuries.

The properties that make plastic so versatile are now contributing to human health problems and environmental issues:

- Plastic that ends up in bodies of water is ingested by marine life, which can harm or poison them.
- Floating plastic debris, which can persist in water bodies for thousands of years, allow for the transportation of invasive species, which disrupt natural habitats.
- Plastic in landfills can leach chemicals into the groundwater and be absorbed by humans. This can alter hormone levels and cause other adverse health effects.
- Eight percent of the world’s oil resources are used to generate new plastic items.

Humans are constantly exposed to plastics. 80% of newborns and nearly 100% of adults have measurable levels of plastic compounds in their bodies. Environmental plastic exposure in animals has led to problems with reproduction and development, and human exposure has been linked to increased heart rate and diabetes.

Plastics account for 10% of the world’s generated waste, most of which is sent to landfill after use. The volume of generated plastics is increasing at a rate of 9% per year. It is important to address the issue of the sustainability of plastic. Recycling must be encouraged for all plastic products. Used plastic should be thought of as a raw resource with which to manufacture new plastic, not as waste to be discarded.

In summary, according to Environmental Health News (2009), plastics existing in the environment, due to lack of recovery, present health issues for both animals and humans. It would be extremely beneficial to recover and recycle as many plastic items as possible in order to prevent environmental contamination and to reduce the amount of crude oil required to manufacture new plastic products.

## 2.6 BENEFITS OF ENVIROMENTAL MANAGEMENT SYSTEMS

According to the Commission for Environmental Cooperation (2005), a properly implemented EMS has the potential to greatly affect an organization in the following ways:

### 1) Reduced costs, resource use, and waste generation

Decreasing material consumption and waste generation will lower costs. If fewer materials are consumed, fewer replacement materials must be purchased. Waste removal is charged for by mass, therefore, the less waste is generated, the lower the removal costs.

### 2) Regulatory compliance

Legislation currently exists to govern the basic environmental performance of all Canadian hospitals. Implementing an EMS will ensure that all existing regulations are followed. In the event that the government issues more stringent guidelines for hospitals, the test hospital will be prepared due to the EMS.

### 3) Employee Involvement

The successful implementation of an EMS requires employee responsibility and participation. This creates a sense of accomplishment and morale among staff members. The health of the environment has become a popular notion, and a sense of wellbeing should be derived from reducing environmental impacts.

#### 4) Improved Public Image

The implementation of an EMS will showcase the test hospital's commitment to the environment. This will create a highly-accepted and appreciated public image.

In summary, the Commission for Environmental Cooperation (2005) reports that the implementation of an EMS will lead to reduced waste generation (and subsequently reduced waste removal fees), increased regulatory compliance, employee involvement and satisfaction, and an improved public image.

## 2.7 DEVELOPING AN ENVIRONMENTAL MANAGEMENT SYSTEM FOR A UK HOSPITAL TRUST

Douglas and Meltzer (2004) present a case study on the implementation of an EMS in a UK hospital. Their findings are summarized below:

Salford Royal Hospitals National Health Service Trust (SRHT), located in the United Kingdom, was a 900-bed, 3,500-staff teaching hospital at the time of the case study. In 2002, SRHT developed and implemented an EMS in an attempt to reduce their environmental impact. The obstacles encountered during the implementation process were mostly due to the politics associated with large organizations. A hospital's main objective is to provide clinical healthcare to its patients, and this dominates over other objectives. The introduction of an EMS was seen as secondary in priority to the primary goal of healthcare delivery. While the health of patients is of utmost importance, the health of the environment is an increasingly significant factor, and can contribute to medical issues in humans, bringing the problem full-circle.

SRHT determined that environmental impact should be treated as a risk and included in the hospital's risk management program. This ensured that the initiatives would be enforced and the hospital would be in compliance with environmental legislation. Various aspects of SRHT's impacts (waste generation, energy consumption, water usage, etc.) were reviewed, and priorities were set based on the areas with the most damaging environmental performance.

SRHT established a green team, consisting of staff representatives from various units, to cooperatively oversee the implementation of the EMS. Members of the green team were responsible for educating staff prior to initiative implementation and answering any questions that may arise regarding the EMS process.

By following the steps required to implement an ISO 14001 EMS, and by persevering when faced with political obstacles, SRHT effectively established a system to improve their environmental performance. The organization observed documented reductions in waste sent to landfill and incineration, as well as a boost in staff morale stemming from the collective desire to improve environmental health.

In summary, Douglas and Meltzer (2004) report that while patient care is the main priority for healthcare providers, it must be recognized that polluting the environment will negatively impact patient health. Hospital politics can be daunting, but by persevering and following the ISO14001 framework, a successful EMS was implemented and a reduction in landfilled waste was observed.

## 2.8 STRUCTURE OF A GENERAL EMS

According to the European Commission (2013), an Environmental Management System is a tool used to manage and improve an organization's environmental performance. While various EMS frameworks exist, each follows the general principals of the "Plan-Do-Check-Act (PDCA) Cycle", as shown in Figure 1.


**Figure 1: Structure of General EMS (PDCA Cycle)**
Image from the European Commission

The steps in the PDCA cycle are as follows (European Commission, 2013):

1) **Plan:** An environmental policy, including objectives and targets, is created. Action plans are set in place to address various environmental issues (for example, lack of recycling).

2) **Do:** Initiatives meant to rectify environmental issues, as addressed in Step 1 (Plan), are implemented. Resources are allocated to achieve proposed initiatives, and responsibilities are assigned to ensure success. All affected staff must be properly trained on the new initiatives, using effective communication.

3) **Check:** The results of the newly-implemented initiatives must be analyzed to confirm that the change resulted in an improvement. Results can be determined through monitoring, staff feedback, and auditing.

4) **Act:** If the initiatives did not result in an improvement, the process must be reconfigured and started anew (back to Step 1: Plan). If the initiatives did in fact result in an improvement, there is always room to do better. This step requires constant review of environmental performance to determine if there is anything else that can be improved upon.

The PDCA cycle sets the grounds for the structure of a general EMS. This can be used as a stepping stone toward a more intricate and recognized EMS, such as ISO 14000, EMAS, or BS 8555.

## 2.9 THE ISO 14001 EMS MODEL

In North America, the ISO 14001 model is the most popular form of EMS. According to the International Organization for Standardization (2011), an EMS meeting the ISO 14001 standard enables an organization to:

1) Identify and control the environmental impact of its activities, products or services;

2) Continually improve its environmental performance;

3) Implement a systematic approach to setting environmental objectives and targets; and

4) Demonstrate that these environmental objectives/targets have been achieved.

### 2.9.1 STEPS TO IMPLEMENTING AN ISO 14001 EMS

Figure 2 illustrates the five major sections of the ISO 14001 EMS model:

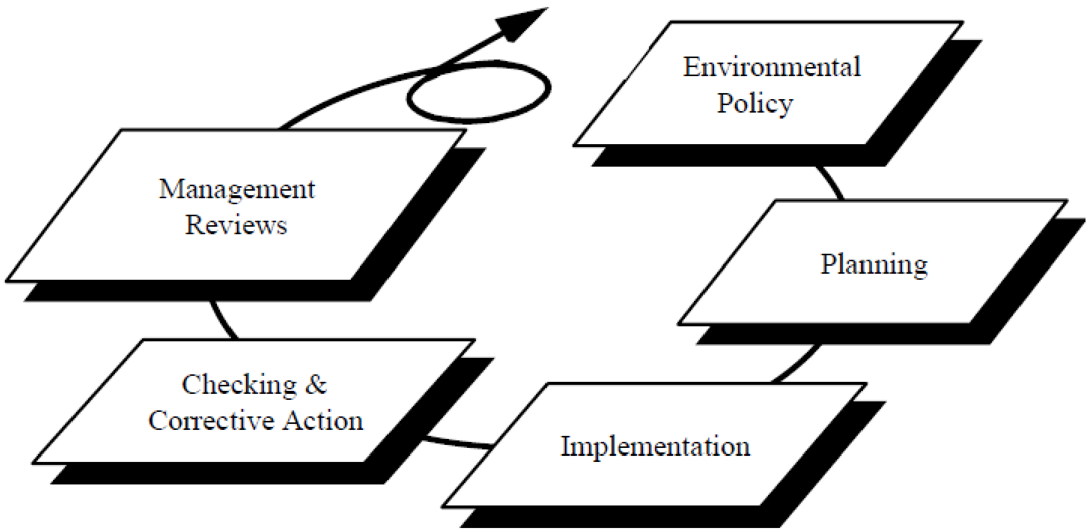



**Figure 2: Five Main Sections of ISO 14001 EMS Model**
Image from Five Winds International

To successfully implement an ISO 14001 EMS, the five steps highlighted in Figure 2 must be implemented (Five Winds International, 2004). A detailed explanation of the action required at each step is as follows:

**1) Environmental Policy**

- Effectively communicates the organization's commitment to continuously reducing their environmental impact.
- Identifies existing legal environmental requirements with which the organization must comply.

**2) Planning**

- Identifies environmental issues and defines the initiatives required to meet the organization's goals as set out in the environmental policy.
- Defines possible projects/processes that will yield the desired result of improved environmental performance.
- Staff training is required to effectively communicate the new strategy with employees and ensure compliance.
- Documentation of the EMS is required to ensure consistency and formality.

**3) Implementation**

- Describes procedures necessary to implement the desired initiatives.
- Identifies individual responsibilities for accomplishing goals.

**4) Checking and Corrective Action**

- Monitors the organization's environmental performance subsequent to the implementation of environmental initiatives. If the outcome of an initiative is not as predicted, corrective action can be taken to improve the results.
- If a sector is found in non-compliance, action must be taken to ensure total staff participation.

**5) Management Reviews**

- Evaluation of the EMS to determine its effectiveness in reducing negative environmental impacts and continuously improving the organization's performance.
- ISO 14001 certification requires an annual EMS audit and review.

### 2.10 THE EMAS SYSTEM

According to the European Commission (2013), the Eco-Management and Audit Scheme (EMAS) can be voluntarily adopted by organizations in an effort to improve their environmental and economic performance, while communicating these achievements to the public. EMAS encompasses three key elements, as described below:

1) **Performance:** each year, the organization must update its environmental policy, as well as report on achieved targets and plans for future improvement.

2) **Credibility:** independent third party auditors review and verify the environmental performance and claims made by the organization in order to maintain credibility.

3) **Transparency:** the organization must release its environmental statement, policy, and performance review to the public. This ensures that stakeholders are aware of the organization's performance, and motivates the organization to perform to the best of their ability.

#### 2.10.1 STEPS TO IMPLEMENTING AN EMAS SYSTEM

EMAS is not specifically a type of EMS, but it includes the implementation of an EMS as part of its many requirements (Commission for Environmental Cooperation, 2005). To successfully implement an EMAS system, the following steps must be undertaken:

1) **Environmental Review:** The organization must consider and evaluate all of its environmental impacts, including those related to facility activities, products and services, and existing environmental management practices. It would also be pertinent

to evaluate the methods currently in place to monitor and report environmental performance.

2) **Environmental Policy:** The organization must create a policy which outlines their commitment to comply with all applicable environmental legislation, as well as to strive for and achieve continuous progress in environmental performance.

3) **Environmental Program:** The organization must develop a document that describes its specific environmental goals and targets. This will help them to plan and implement new initiatives that will lead to the realization of their goals.

4) **Environmental Management System:** Based on the results of the Environmental Review, the organization must enact an EMS to help them reduce their environmental impacts and continuously improve their performance. The EMS will prescribe responsibilities, action plans (based on the Environmental Program), procedures and training requirements associated with new initiatives, methods to monitor performance, and communication plans.
5) **Environmental Audit:** the organization must perform an audit to assess the EMS and determine how well the facility's goals are being met, policy is being followed, and regulatory requirements are being achieved.

6) **Environmental Statement:** the organization must create and release a document highlighting its environmental performance, including the results of the initiatives and whether goals were attained. The statement must also include future objectives towards which the organization will be working to achieve continuous improvement.

7) **Accreditation:** following the implementation of the previous steps, the organization's actions and documents must be verified by an approved third party. Upon approval, the organization can officially claim to be EMAS-accredited, and may use the EMAS logo in their publications.

While EMAS requires organizations to address all of their environmental issues (i.e. waste management, energy usage, etc.), they are not required to do so all at once. The aspects of the organization's operations that create the greatest environmental impacts are focused on first, and once these items are under control, new initiatives can be undertaken to expand the program (Institute of Environmental Management & Assessment, 2011).

EMAS relies heavily on employee involvement for its success. Each staff member, from the board of executives to all levels of management and frontline staff, must participate in the new initiatives if the program is to achieve environmental success (IEMA, 2011).

According to the Institute of Environmental Management & Assessment (2011), only organizations based within the European Union are eligible for true EMAS registration and certification. This means that the test hospital is not eligible for environmental certification using an EMAS system.

## 2.11 THE BS 8555 EMS MODEL

The British Standard, *Guide to the Phased Implementation of an Environmental Management System Including the Use of Environmental Performance Evaluation* (BS 8555), is another type of EMS that is used to control the environmental performance of an organization.

This system incorporates a generic EMS, which is not certifiable by a third party (ENDS 337, 2003). However, the BS 8555 EMS can easily be upgraded to ISO 14001 or EMAS. BS 8555 focuses on delivering measurable environmental and financial benefits for the organization, delivering environmental performance data for public reporting, and creating credibility and a competitive edge for the organization. BS 8555 organizations encourage their suppliers and vendors to improve their environmental performance and to provide more sustainable products (ENDS 337, 2003).

### 2.11.1 STEPS TO IMPLEMENTING A BS 8555 EMS

BS 8555 is achieved by an organization over several phases, as shown in Figure 3:

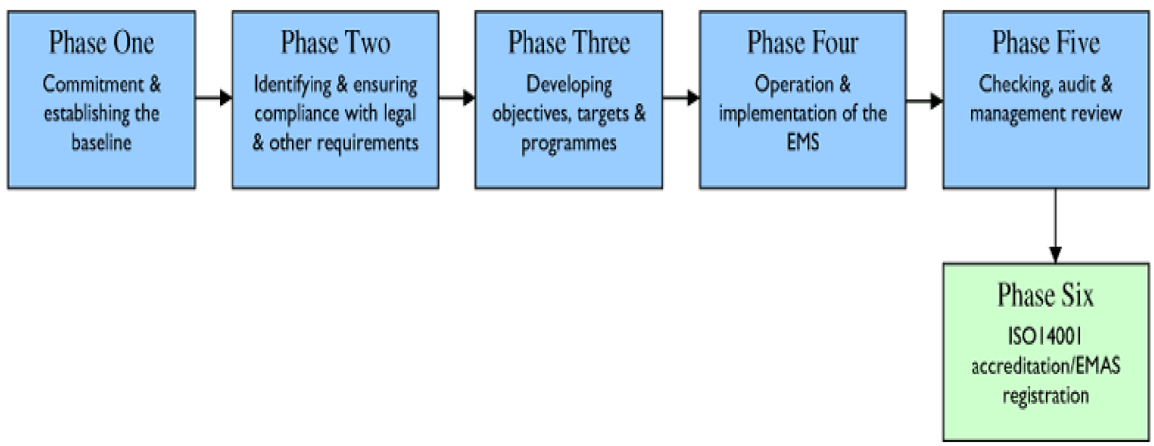



**Figure 3: Six Phases of BS 8555 Implementation**
Image from the Institute of Environmental Management & Assessment

An explanation of the steps required to implement the BS 8555 system, according to the Institute of Environmental Management and Assessment (2011), is as follows:

1) **Commitment and Establishing the Baseline:** In Phase 1, the organization must commit to managing their environmental performance. The main environmental issues must be identified, as well as initiatives that will help address these issues. Employees

must be recruited for participation in new procedures, as well as to lend input into what needs to be done to make the organization a more environmentally-friendly facility. In this Phase, the EMS and environmental policy must be drafted and prepared for implementation and release.

2) **Identifying and Ensuring Compliance with Legal Requirements:** In Phase 2, the organization must identify all environmental regulations that must be abided by. By recognizing what performance is legally mandated, the organization can implement the necessary initiatives to remain in compliance with these requirements. The organization must generate an action plan to deal with non-compliance and to reward those who follow the plan.

3) **Developing Objectives, Targets and Programs:** In Phase 3, the organization must build on what they drafted in Phase 1 to establish the key features of their EMS (objectives/targets, and how they will be achieved). This should be updated on a regular basis to allow for continuous improvement of environmental performance. Responsibilities for the carrying out of these action plans must be assigned, and proper staff training must be allocated. The Environmental Policy (as drafted in Phase 1) must be finalized and released to appropriate stakeholders. Environmental performance indicators must be determined, as this will help the organization conclude whether the environmental initiatives resulted in an improvement (for example, waste hauling records can be reviewed to determine the amount of waste sent to landfill).

4) **Implementation and Operation of the Environmental Management System:** In Phase 4, the organization must fully implement their general EMS, based on the Plan-

Do-Check-Act scheme. All employees must be aware of their roles within the EMS to ensure success.

5) **Checking, Audit and Review:** In Phase 5, the organization must audit and review their environmental performance in order to determine the effectiveness of their EMS. If flaws are detected in the EMS, corrective measures must be taken to rectify the situation. This should be done on a semi-regular basis to facilitate continuous improvement.

6) **Environmental Management System Upgrade:** In Phase 6, the organization has the opportunity to upgrade their BS 8555 EMS to either an accredited ISO 14001 or registered EMAS, at the discretion of an external auditor/verifier. If the goal is to acquire EMAS certification, the organization will have to prepare an Environmental Statement.

After each BS 8555 implementation phase, the organization must conduct an audit of the actions taken during the phase. This can be done internally, or by a third party reviewer, with the goal of ensuring that the requirements for the specific phase have been met before moving on to the next phase.

The stepwise approach to BS 8555 implementation is ideal for financially challenged organizations. The facility may undertake one phase, and choose to wait to implement the next phase until the appropriate resources become available. This is appealing for organizations (such as Canadian hospitals) which do not have the funds to implement a full EMS all at once.

# CHAPTER 3

# DESIGN AND METHODOLOGY

## 3.1 DEVELOPING THE STRUCTURE OF THE HEMF

Although an EMS can be limiting in some aspects, it would be beneficial for the test hospital to incorporate elements of the ISO 14001 EMS model into the HEMF. With respect to other current EMS approaches, EMAS is only recognized within the European Union (IEMA, 2011), and BS 8555 is not a certifiable EMS model (ENDS 337, 2003). However, certain elements of the EMAS and BS 8555 systems can be included to improve the overall effectiveness of the HEMF.

### 3.1.1 ELEMENTS OF EMAS AND BS 8555 TO INCORPORATE INTO HEMF

The EMAS and BS 8555 systems contain elements that would increase the effectiveness of the ISO 14001 model. These factors were encompassed in the design of the test hospital's HEMF, and include:

**1) Environmental Statement (EMAS)**

The EMAS model requires the creation and release of an annual Environmental Statement, highlighting the organization's environmental performance. If initiatives were undertaken, the results of these must be made available, as well as the rate at which goals were met (or not met). This forces the organization to perform to the best of their ability, as they are being held publicly accountable.

**2) Environmental Review (EMAS)**

EMAS requires an organization to undertake a review of all its environmental impacts, and address each accordingly. ISO 14001 does not require an Environmental Review, but it is necessary to establish which environmental aspects require attention. Without fully investigating which impacts require mitigation, there will undoubtedly be some left out. While every environmental issue must be handled through EMAS, they do not have to be addressed all at once. For the purpose of this thesis, the HEMF will be developed to address the issue of waste management only. In the future, the HEMF can be expanded to include other environmental impacts, such as air emissions, water usage, and energy consumption.

**3) Stepwise Approach to Implementation (BS 8555)**

If funding is not immediately available for HEMF implementation, organizations will not be able to afford to execute the entire system simultaneously. The BS 8555 model utilizes a stepwise approach, whereas the organization can implement the HEMF in a series of phases. Upon the completion of one phase, the next phase can be put off until the appropriate resources become available. Canadian hospitals do not have an abundance of available funds, and will benefit from the opportunity to implement their HEMF in phases.

**4) Employee Involvement (EMAS)**

The EMAS system emphasizes the importance of employee involvement throughout the HEMF implementation phase. If staff members do not participate in new environmental initiatives, goals will not be attained, and the HEMF will not succeed. It is important for all employees (from top-level executives to frontline staff) to be engaged in the environmental movement to ensure its success.

### 3.2 TEST HOSPITAL'S HEMF

In keeping with the general ISO 14001 EMS framework (as described in section 2.9.1), and with the addition of the aforementioned elements from the EMAS and BS 8555 systems, the test hospital's HEMF is illustrated in Figure 4, and is described below:

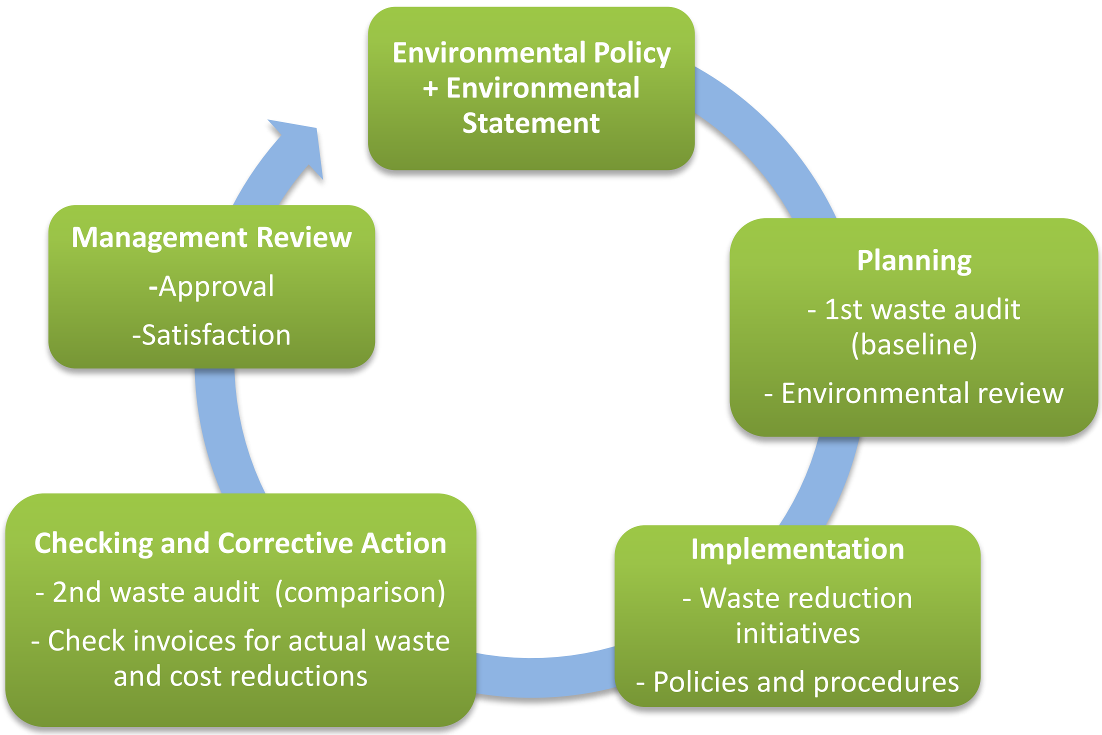



**Figure 4: Test Hospital's HEMF**

#### 3.2.1 ENVIRONMENTAL POLICY

The environmental policy that will be released to hospital staff, physicians, and volunteers can be found in Appendix A. This policy demonstrates the test hospital's commitment to improving their environmental performance, and will provide motivation to achieve the published goals.

### 3.2.2 ENVIRONMENTAL STATEMENT

In order to keep hospital employees and the public informed on the hospital's environmental performance, an annual environmental statement must be generated and released. With the knowledge that environmental performance will be scrutinized by the public, employees will be motivated to improve their practices to the utmost.

For the purpose of this thesis, the environmental statement will focus on solid waste management, but future expansion of the HEMF would lead to a statement regarding the organization's total environmental performance. See Appendix B for the test hospital's Environmental Statement.

### 3.2.3 PLANNING

Prior to the execution of the HEMF, several processes must be undertaken to prepare for successful implementation, including:

**1) Initial Waste Audit to Establish Baseline Waste Composition**

In order to determine the baseline of generated waste amounts, an initial audit must be conducted on the hospital's waste. All waste generated by the hospital over a 24-hour period was collected and sorted into various categories (i.e. metal, glass, plastic, etc.). The separated waste was weighed to determine the composition of the hospital's waste stream. This audit will highlight which waste components are prevalent and require attention for reduction.

**2) Environmental Review to Target Areas for Improvement**

A process review is necessary to physically establish which areas of the hospital require the greatest attention. It is important to observe the processes of individual departments to determine which areas generate the most avoidable waste. This will indicate where the most emphasis on waste management needs to be placed. While this thesis focuses solely on solid waste management, the HEMF can be expanded in the future to include all environmental impacts (water, energy, pollution, etc.). In this case, a full environmental review would be required to determine which negative impacts are present and require mitigation, leading to an expanded set of environmental initiatives suggested for implementation.

### 3.2.4 IMPLEMENTATION

Several waste management strategies and projects were implemented in order to reduce the hospital's unnecessary outputs. An environmental review was undertaken to determine which environmental issues required attention. The entire hospital was toured to pinpoint the areas which presented the poorest environmental performances. Priority was given to these areas, as the large margin for improvement would yield the most positive impact on the environment. Readily-available technology and equipment made it possible to address issues that otherwise may not have been as easily resolved.

#### 1) Implementation of a Green Team

Prior to the research, no environmental initiatives were taking place at the test hospital. A dedicated group of staff was formed to keep environmental initiatives on track and to respond to questions from hospital employees throughout the project. A group setting boosted morale and offered support during project implementation and continuation. The test hospital's inaugural Green Team consisted of over 10 representatives from various areas and departments (dietary, environmental services, maintenance, nursing, management, laboratory, executive, etc.). Team members brought forward environmental issues from their specific areas and units, and the group was able to brainstorm and determine solutions to the issues.

**2) Blue Wrap Recycling**

Instrument trays are bound in “blue wrap” to keep them sterile. Prior to the research, all blue wraps (#5 plastic) generated by the hospital were sent to landfill, where they will take hundreds of years to degrade (Saskatchewan Waste Reduction Council, 2008). The test hospital has partnered with a qualified waste management provider to recycle their blue wrap and divert mass amounts from landfill annually.

**3) Composting**

Prior to the research, the hospital’s kitchen processed all of its food waste with the use of a pulper, which mulched up the food. This food mulch was collected and sent to landfill. The hospital is charged by weight for the removal of waste, and food scraps are the heaviest component of the waste stream. To divert organics from the waste stream, and to significantly reduce the cost of waste removal, two in-vessel composters were installed in the Dietary department. The composters each convert 250 pounds of organic waste into fertilizer in a 15-hour period, reducing mass by 90%. Agitators break down the food into small particles, which are heated to 180°F/82°C. This decomposes and deodorizes the organics, while sterilizing and killing bacteria, meaning that even food that has come into contact with infectious patients can be safely composted. The fertilizer is being donated to a local non-profit organization which grows produce for those in need in the community. The test hospital has become only the second hospital in Canada to implement this technology.

In-vessel composting was required over traditional composting, as the hospital has considerable space and time constraints. The composting machines are the size of a kitchen stove, and fit easily into a room adjacent to the Dietary department. The in-vessel units will convert food waste to fertilizer in 15 hours. The hospital's kitchen operates 365 days per year, and the timely conversion of food waste is essential. For these reasons, it was necessary to implement in-vessel composting.

**4) Enforcement, Promotion, and Upgrade of Traditional Recycling**

When the research began, the hospital was limited to what they could recycle (paper, cardboard, metal, glass, and #1, 2, and 5 plastic). They were also paying a recycling provider upwards of $10,000 per year to remove their recyclables, while receiving no rebates. The hospital now has the City pick up their recyclables at no cost, and has switched to a separate provider to remove their cardboard (who provides significant rebates). The City will accept far more items for recycling than the previous provider: paper, plastic (all varieties except plastic film), glass, and metal. Promotion of this program, as well as staff, patient, and visitor education and more accessible recycling bins has increased recycling compliance.

**5) Reusable Pharmaceutical Containers**

Unused medications must be securely disposed of in a pharmaceutical container to prevent them from ending up in the wrong hands. Prior to the research, the hospital's plastic pharmaceutical containers were incinerated along with their contents. Reusable pharmaceutical containers have been purchased to replace the disposable variety throughout the hospital. When the new containers are full, the contents are incinerated and the container is sterilized and returned for reuse. This will prevent the incineration of hundreds of plastic containers each year, and will eliminate the need to create new pharmaceutical containers for the hospital's use. The test hospital is among the first facilities in the country to implement this type of reusable pharmaceutical container.

**6) Bagless Biomedical Waste Containers**

On regular nursing units (with patient beds), biomedical waste is a rare occurrence and is well controlled (there is a single biomedical waste bin for each unit, and biomedical waste is discarded there as needed). However, in the hospital's 26-station dialysis unit, the biomedical waste situation could be described as "out of control". There were no garbage or recycling bins, only 26 (one per chair) open-top biomedical waste bins lined with yellow bags, meaning absolutely all waste went into the biomedical bins. The yellow bags were removed from the bins and sent for incineration (the hospital was incinerating over 16,000 plastic bags annually).

Biomedical waste is 14 times more expensive to dispose of than regular waste, and recycling is free for the test hospital. It was important to reduce and sort what was being disposed of in the biomedical waste bins, so all refuse could be dealt with accordingly (uncontaminated plastics, paper, metal, and glass should be recycled, not sent away as biomedical waste). All 26 open-top biomedical waste bins were removed, and bagless biomedical waste containers (one for every 3 dialysis chairs), along with regular waste and recycling bins were implemented.

The new biomedical waste containers require a foot pedal to be depressed to open the lid, and this manual input is hypothesized to act as a deterrent to putting all waste into the biomedical waste stream. Also, by having fewer biomedical waste bins available and providing regular waste and recycling bins, it is expected that waste is more appropriately sorted. When the new bagless biomedical waste containers are full, the contents are incinerated and the container is sterilized and returned for reuse (no more wasting thousands of plastic bags).

**7) Bedpan Flushers**

Prior to the research, nursing staff were manually cleaning soiled bedpans. This can lead to contamination of the healthcare provider due to aerosol spray (Gerba et al, 1975). It was an extremely unpleasant and unsafe task. To avoid manually cleaning soiled bedpans and becoming contaminated, frontline staff often threw used plastic bedpans and urinals in the trash (this was observed in the first waste audit). Thirteen automated hands-free bedpan flushers have been ordered (one for each nursing unit that utilizes bedpans). Nurses will no longer have to manually wash bedpans. This is hypothesized to reduce the number of bedpans/urinals thrown in the trash. It also significantly reduces the contamination risk to healthcare providers (bedpans/urinals go into the flushers full, so nurses no longer have to empty them).

**8) Aqueous Ozone Cleaning Solution**

At the onset of the research, the test hospital used a wide variety of harsh chemicals to disinfect all areas of the organization. Aqueous ozone has been proven to be a natural disinfectant that kills bacteria and viruses, all while containing zero toxins or irritants (Zuma et. al., 2009), and remains stable and effective at achieving disinfection for 24 hours after it is dispensed. Twenty-five aqueous ozone dispensers were purchased and installed in the hospital’s housekeeping closets. Currently, aqueous ozone is approved for use on all surfaces in non-patient care areas (offices, hallways, public washrooms, elevators, waiting rooms, etc.) and floors in patient rooms. The hospital has been able to completely eliminate the use of chemicals in public areas, and has eradicated the chemical that was previously used on floors. Full Health Canada approval for ozone use on all surfaces, including in patient rooms, will occur in the near future. At this time, the test hospital will be the first hospital in Canada to be fully equipped with ozone dispensers, and will eliminate the use of all chemicals. The use of aqueous ozone creates a healthier work environment for housekeepers who previously inhaled chemicals while on the job (not to mention sick patients being excessively exposed to chemicals). By eliminating the use of chemicals, there will be significantly fewer plastic bottles, dispensers, and cardboard boxes produced that may end up in landfill.

**9) Operating Room Recycling**

The fast-paced, hectic nature of the Operating Room previously led to an unwillingness and often inability to recycle. Strategic use of bins, education, and a staff morale boost led to a recycling revolution in the OR, where they are now recycling a large amount of their waste and diverting otherwise landfill-bound materials.

### 3.2.5 POLICIES AND PROCEDURES

The HEMF initiatives would not be successful without employee participation. To promote staff acceptance and participation, in-service training and enthusiastic promotion for each initiative was provided. Furthermore, a complete policy and procedure was published for each new initiative. The procedures explain the correct methodologies for undertaking new processes (i.e. composting, automated bedpan flushing, etc.), while the policies communicate the hospital’s commitment to participation. See Appendix C for the complete set of policies and procedures stemming from the HEMF initiatives.

### 3.2.6 CHECKING AND CORRECTIVE ACTION

After the waste management projects were implemented and in use for some time, a second waste audit was conducted in order to determine the achieved degree of improved waste composition. A successful HEMF decreases the amount of waste generated. The hospital's waste and recycling invoices were reviewed to determine whether the waste reduction initiatives led to financial savings.

### 3.2.7 MANAGEMENT REVIEW

Following implementation of the HEMF and its corresponding waste reduction initiatives, management (supervisors, managers, and directors) must review the procedures to ensure that they are comfortable, achievable, and optimized for their employees. It is imperative that the process be tailored to those who are actually performing the tasks associated with the waste management initiatives; otherwise the HEMF will not be successful.

The management review (with staff input) may uncover areas for improvement, which is essential in ensuring the success of the initiatives. What is unknown cannot be changed or improved upon.

## 3.3 ONTARIO HOSPITAL ASSOCIATION (OHA) GREEN HOSPITAL CHAMPION FUND IMPLEMENTATION PROGRAM AWARD

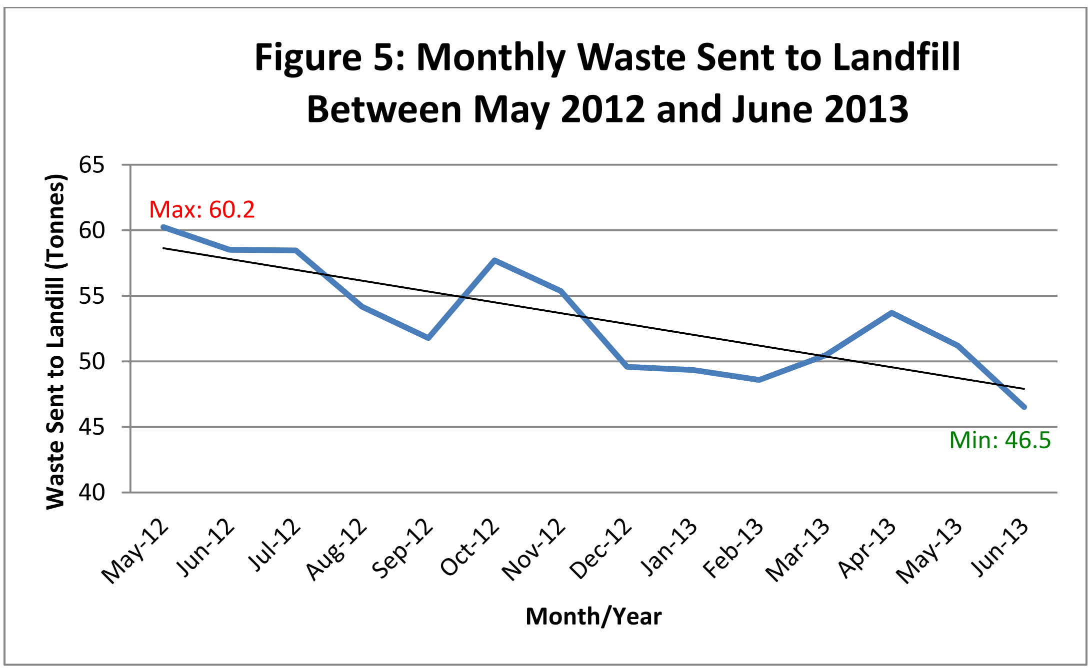
In August 2012, the OHA held a competition for Ontario hospitals to apply for funding to enact environmental initiatives at their facilities. Over fifty hospitals applied, and only five were chosen to receive funding. I was the primary author on the funding application. The test hospital was awarded $439,548.00 to implement the planned HEMF. This award lends external validation to the project: the OHA, which oversees all of Ontario's hospitals, considers this research worthy of significant funding. The development of a successful HEMF for hospitals has the potential to benefit a wide variety of healthcare organizations. Without this generous donation from the OHA and the Ontario Ministry of Finance, much of the equipment required (composters, bedpan flushers, etc.) could not be purchased.

# CHAPTER 4

# OUTCOMES OF HEMF IMPLEMENTATION

## 4.1 DECREASED LANDFILLED WASTE AND INCREASED RECYCLED MATERIAL

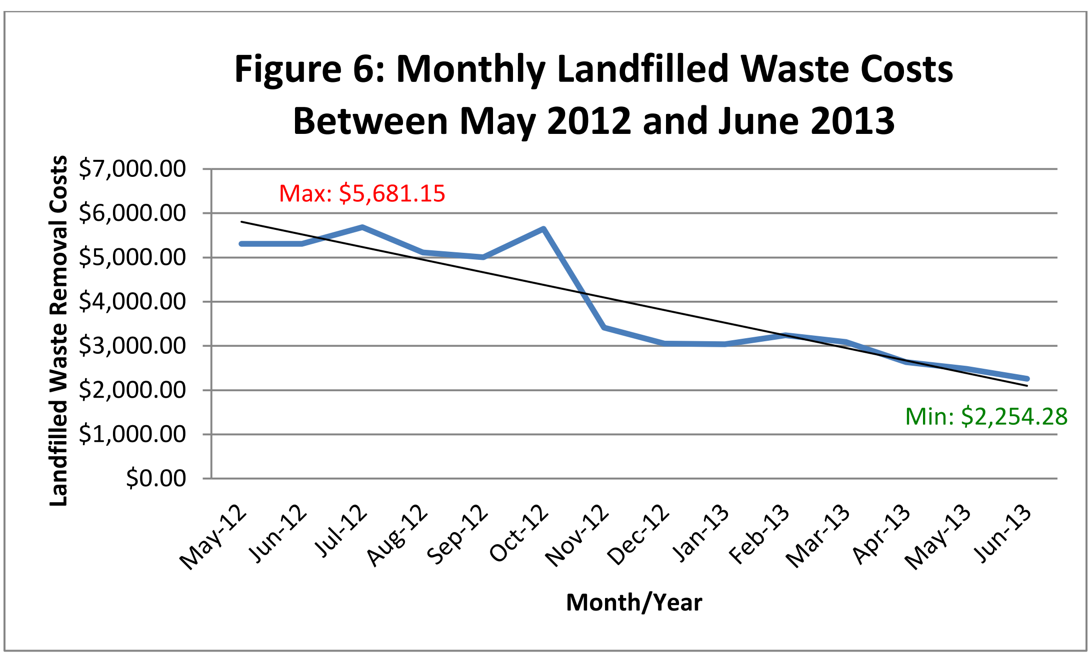
The main objective of this research was to reduce the amount of waste generated and sent to landfill by the test hospital. Through the implementation of several waste reduction initiatives following an environmental management system framework, a marked decrease in landfilled waste was achieved. The waste and recycling invoice data from May 2012 (at the onset of the research) to June 2013 were analyzed to determine the trend in landfilled waste reduction and increased recycling. Figure 5 shows the decreasing amount of waste sent to landfill each month by the test hospital.




As a result of reduced waste sent to landfill, as well as a switch in waste providers, the test hospital’s monthly landfilled waste costs has dropped considerably. At the onset of the research, the hospital was partnered with a vendor who charged $275 per compactor lift (with two scheduled lifts per week) and $45 per tonne of waste removed. On November 1, 2012, the hospital switched to an interim vendor who charged $115 per compactor lift and $43 per tonne of waste. Finally, on April 1, 2013, the test hospital entered into a contract with a waste provider who charges $63.05 per compactor lift and $34.92 per tonne of waste removed.

Removing waste to landfill, because it is non-hazardous in nature, is generally a straightforward transaction. Therefore, unusual handling capabilities are not required, as with biomedical or hazardous waste. As a result, the lowest common bidder was awarded the waste contract.

The reduction in waste hauling price, coupled with a marked decline in landfilled waste, has resulted in a favourable decrease in monthly waste removal costs, as seen in Figure 6, below:



The initial annual cost savings associated with waste reduction initiatives were extraordinary, since it was originally so expensive to have waste removed. However, the overall cost of waste management at the hospital has still decreased considerably, which is a success in itself.

Prior to the research, the hospital was limited by what they could recycle (paper, cardboard, metal, glass, and #1, 2, and 5 plastic only) based on which vendor was collecting their recycling. Monthly, the recycling provider charged the hospital $20 for tote rental, $86.67 for tote service, $260 for recycling service, and $5 per tote lift. The hospital had 15 totes, which were serviced once a week (this gives a total of 60 tote lifts each month). As a result, the hospital's monthly recycling costs were $666.67.

The research led to the hospital switching recycling providers, which led to an increase in what the organization could recycle, as well as a decrease in recycling costs. The City now removes the hospital's recyclables free of charge, and will recycle far more items than the previous provider: paper, plastic (all varieties except plastic film), glass, and metal. Promotion of this program, as well as staff, patient, and visitor education and more accessible recycling bins, has significantly increased compliance. As previously mentioned, at the onset of the research, the hospital utilized fifteen 96-gallon recycling totes, which were serviced once per week (and which were often not filled). In June 2012, the hospital switched to the City, and increased their recycling bin count to 25, which were serviced once per week. In September 2012, the hospital increased the frequency of their recycling pickups to twice weekly. Finally, in March 2013, the hospital upgraded to recycling pickup 3 times per week. Even still, the recycling totes are often overflowing on pickup day.

Neither the previous recycling provider nor the City weigh the mixed recyclables removed from the hospital. The recycling provider estimates that each 96-gallon tote holds 25 kilograms of recyclable items. This estimate, along with the number of totes and number of pickups, was used to calculate the hospital's monthly amount of recycled material, as shown in Figure 7.

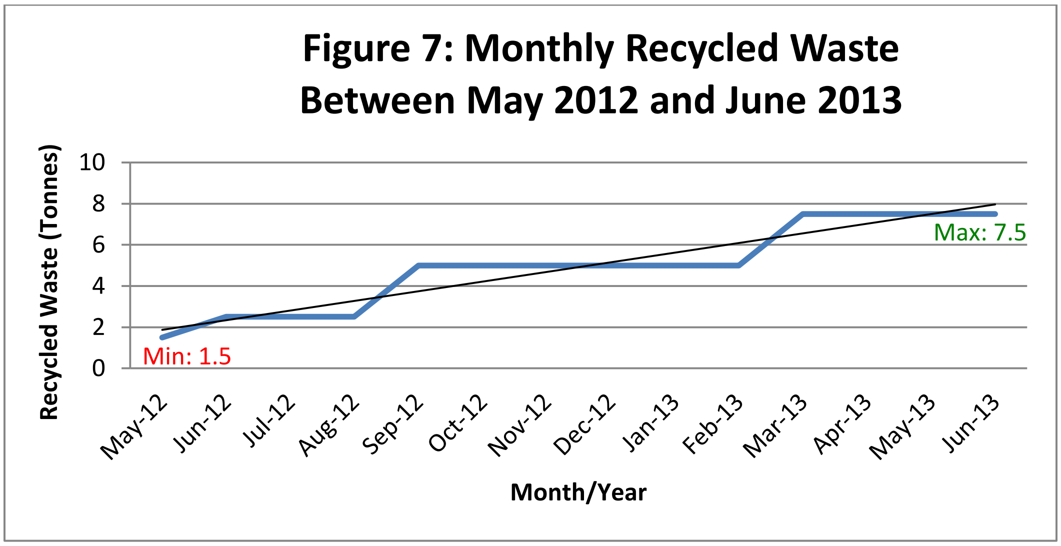
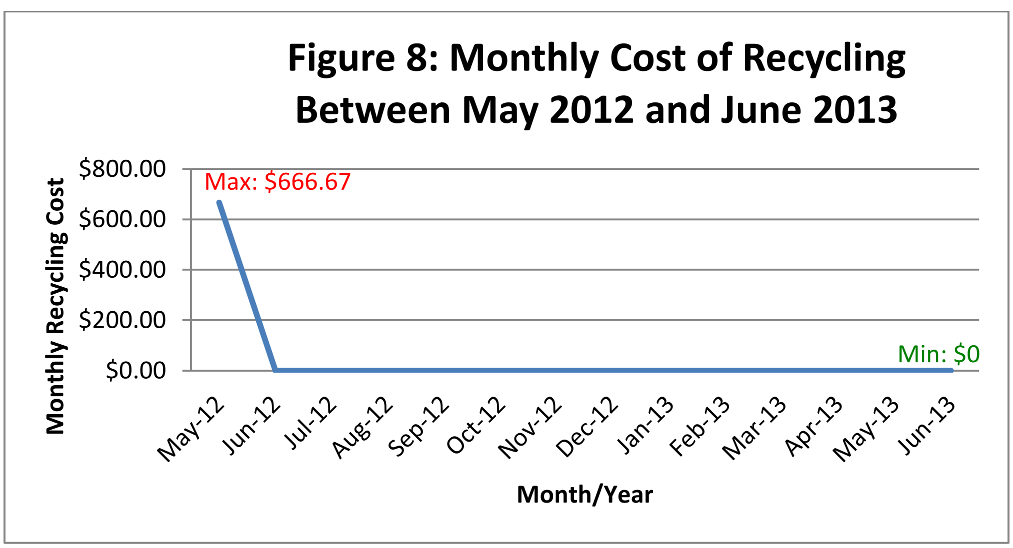



Figure 8 depicts the decrease in recycling costs for the test hospital following the switch to the City for recycling services:



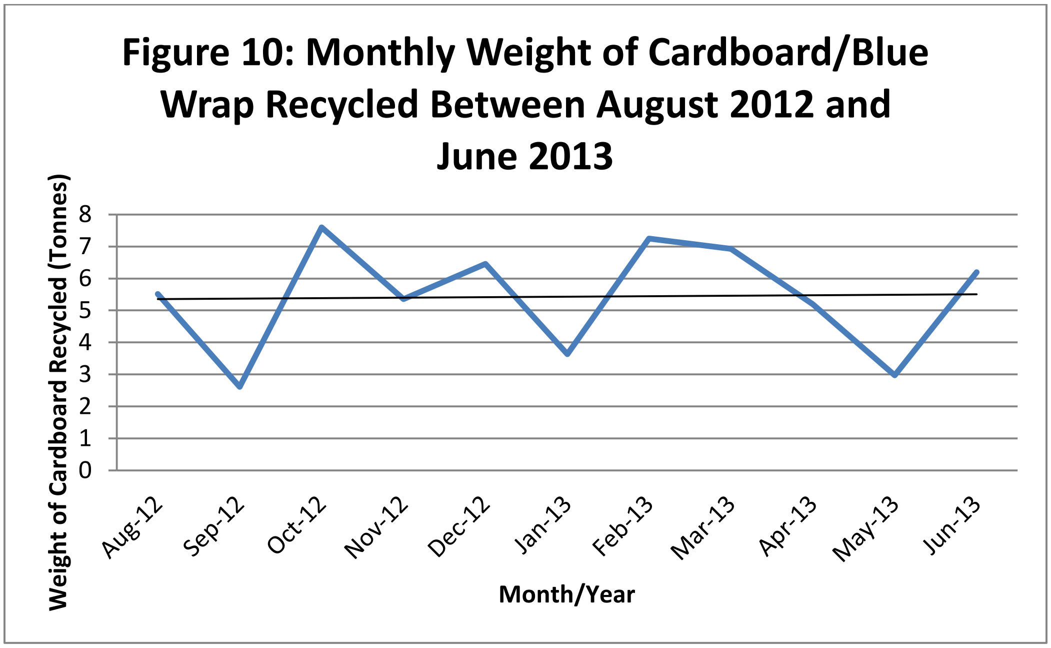
Not only did the total drop in recycling service fees lead to a savings of $666.67 per month, the hospital can now recycle a wider variety of items (at no cost), which leads to less waste being paid to go to landfill and more waste being recycled for free. This presents a further cost savings in landfill fees (and benefits the environment).

When the research began, the test hospital was paying a recycling provider $90 per pickup to empty their cardboard compactor. It is common practice to receive rebates for cardboard recycling because it is easily resold for a high price. However, the existing recycling provider was not offering the hospital a rebate for their substantial amount of cardboard. In August 2012, the hospital switched the service of their cardboard compactor to another vendor, who agreed to accept the facility's blue wrap, as well as provide a rebate for the compactor's contents.

Blue wrap (a #5 plastic) is used to keep surgical instrument trays sterile (Figure 9). Previously, the hospital's blue wraps were all sent to landfill, where they will take hundreds of years to degrade (Saskatchewan Waste Reduction Council, 2008). By recycling their blue wrap, the hospital will divert several tonnes of plastic from landfill annually.

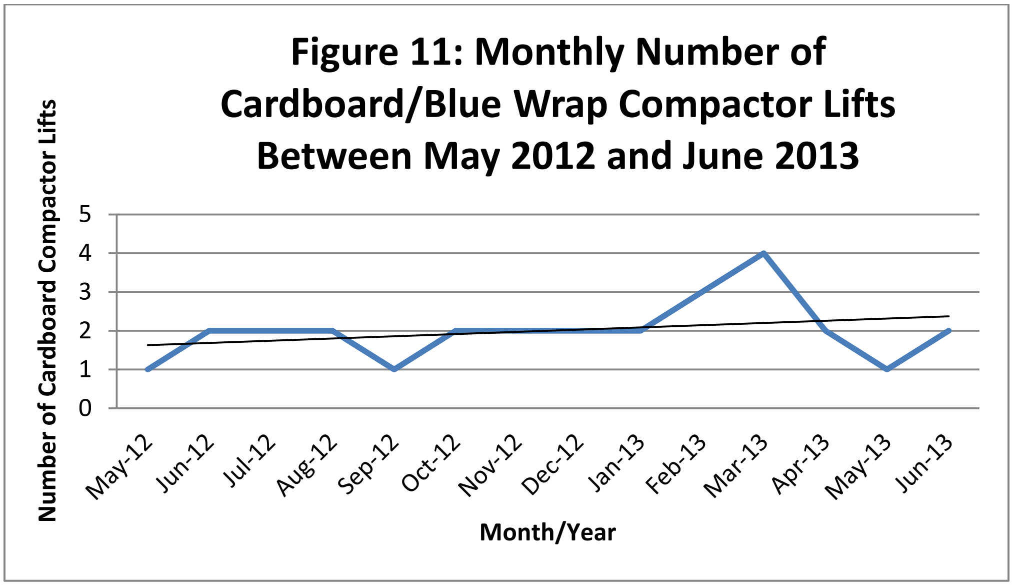
**Figure 9: Instrument Trays Wrapped in Blue Wrap**
Image from challenge.gov

The new provider charges $150 per compactor lift, but provides a rebate of 50% of the monthly market value of cardboard based on the Chicago Stock Exchange. As a result, the cost to have the cardboard compactor emptied has been significantly lowered. Figure 10 depicts the amount of cardboard and blue wrap recycled by the hospital over the research period:

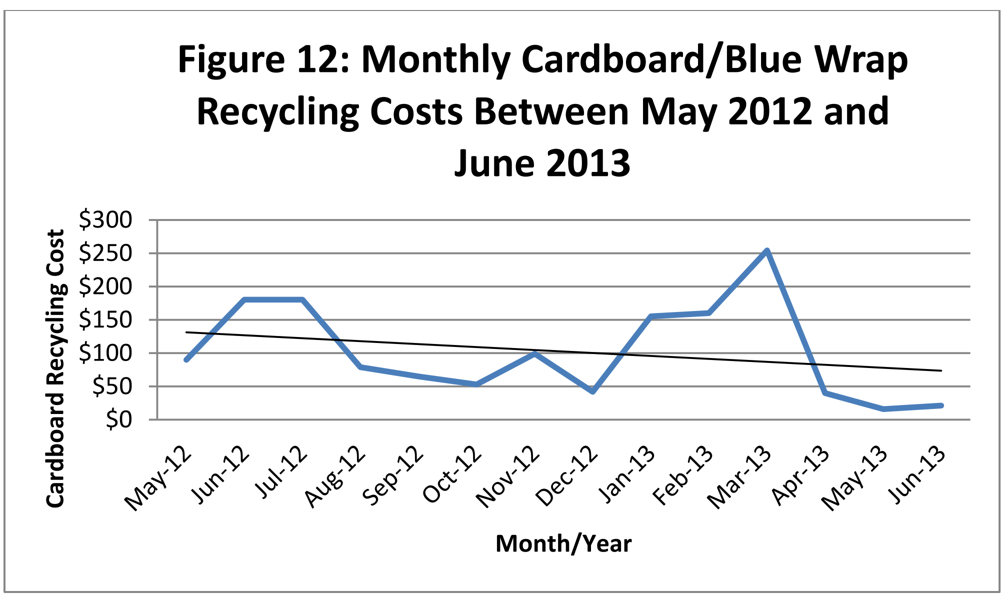



Prior to the August 2012 switch to the current cardboard/blue wrap recycling vendor, the previous recycling provider did not record the weight of the collected cardboard (they simply recorded the number of times they emptied the cardboard compactor). Since a rebate was not given based on tonnage, there was no need to weigh the contents of the compactor. As a result, Figure 10 (above) represents the combined weight of cardboard and blue wrap recycled after the blue wrap recycling initiative began, and does not show the increase from the baseline amount of cardboard recycled prior to the research. Figure 11 (below) depicts the number of cardboard compactor lifts from May 2012 to June 2013.

This shows the increase in cardboard and blue wrap recycling from the onset of the research.




While the amount of recycled cardboard and blue wrap has gone up (leading to an increased number of compactor lifts), the rebates provided by the current recycling provider have led to a cost decrease, as depicted in Figure 12 (below).



The weight of landfilled waste and recycled cardboard/blue wrap varies on a monthly (even daily) basis. Several factors impact the amount of waste and recycling generated by the facility, including, but not limited to:

- the number of admitted patients (patients in beds)
- the condition of patients (some illnesses or injuries require more supplies than others)
- the number of patients seen in the Emergency Department or other out-patient clinics
- the number of surgeries performed (when the eye clinic is running, there are substantially more cases)
- the amount of stock received
- construction projects
- office moves or purges

As a result of the hospital's several variables, the amount of generated waste is not consistent on a monthly basis. However, the trend line shows an overall decrease in landfilled waste, as well as an increase in recycled materials.

## 4.2 INITIAL WASTE AUDIT RESULTS (BASELINE WASTE PERCENTAGE COMPOSITION)

To establish the baseline percentage composition of the hospital's landfilled waste, a waste audit was performed according to Ontario Regulation 102/94 ("Waste Audits and Waste Reduction Work Plans"). O. Reg. 102/94 requires that every Group A, B, or F hospital must perform a waste audit and formulate a waste reduction work plan each year. The test hospital is classified as a "Group A Hospital" (a general hospital that gives instruction to medical students) under Ontario Regulation 964, and is thereby required to conduct an annual waste audit.

O. Reg. 102/94 specifies that waste audits must address the amount, nature and composition of the facility's waste, how and where the waste is produced (including management decisions and policies that relate to the production of waste), and the way in which the waste is managed.

All landfilled waste generated by the test hospital between 7am on May 9$^{th}$, 2012 and 7am on May 10$^{th}$, 2012 was collected and stored in a 12 cubic yard waste bin. On May 10$^{th}$, 2012, this waste was manually sorted into 27 categories to obtain a percentage composition estimate.

The regulation also indicates that waste reduction work plans must include strategies to reduce, reuse and recycle waste, and must identify who will implement each part of the plan, when each part will be implemented and what the expected results are. The 2012 waste reduction work plan included the proposed HEMF initiatives as methods to reduce the amount of landfilled waste. The responsibility for implementation was given to the researcher, with the required participation of staff to facilitate success. A timeline of one year was given for the implementation of initiatives, so their successes could be evaluated by the 2013 waste audit.

The results of the 2012 waste audit are summarized in Table 1.

**Table 1: 2012 Waste Composition Results**

| Category of Waste | Weight of Category in 24-hr Sample (kg) | Percentage of Landfilled Waste |
|---|---|---|
| **Cardboard** | 72.0 | 4.2 |
| **Fine Paper** | 121.0 | 7.0 |
| **Glass** | 17.3 | 1.0 |
| **#1 Plastic** | 25.9 | 1.5 |
| **#2 Plastic** | 28.8 | 1.7 |
| **#5 Plastic** | 28.8 | 1.7 |
| **#6 Plastic** | 31.7 | 1.8 |
| **Hard Plastic** | 69.1 | 4.0 |
| **Newspaper** | 11.5 | 0.7 |
| **Food Waste** | 319.7 | 18.6 |
| **Cans** | 11.5 | 0.7 |
| **Scrap Metal** | 5.8 | 0.3 |
| **OR Wrap** | 118.1 | 6.9 |
| **Electronics** | 1.4 | 0.1 |
| **Confidential Documents** | 5.8 | 0.3 |
| **Examination Gloves** | 72.0 | 4.2 |
| **Diapers** | 57.6 | 3.4 |
| **Food Wrappers** | 11.5 | 0.7 |
| **Paper towels** | 141.1 | 8.2 |
| **Rubber** | 5.8 | 0.3 |
| **Soft Plastic** | 227.5 | 13.2 |
| **Blood-Containing Waste** | 37.4 | 2.2 |
| **Textiles** | 41.8 | 2.4 |
| **IV Bags and Tubing** | 195.8 | 11.4 |
| **Wood** | 1.4 | 0.1 |
| **Styrofoam** | 17.3 | 1.0 |
| **Disposable Hospital Wear** | 40.3 | 2.3 |
| **Total** | **1717.9 kg** | **100%** |

The waste categories highlighted in red in Table 1 represent materials that are not currently recyclable in the test hospital's region. These categories are comprised of waste that was sent to landfill. The waste categories highlighted in green can be diverted from landfill, through current hospital recycling or composting initiatives. As shown in Table 1, 50.5% of the hospital's landfilled waste consisted of divertible materials.

## 4.3 FINAL WASTE AUDIT RESULTS (UPDATED WASTE PERCENTAGE COMPOSITION)

A second waste audit, following identical procedures as the original, was conducted on Monday, July 22, 2013. The results (shown in Table 2) enabled a comparison between the waste composition prior to and following the implementation of the waste reduction initiatives.

**Table 2: 2013 Waste Composition Audit Results**

| Category of Waste | Weight of Category in 24-hr Sample (kg) | Percentage of Landfilled Waste |
|---|---|---|
| **Cardboard** | 12.7 | 0.8 |
| **Fine Paper** | 78.4 | 5.1 |
| **Glass** | 4.2 | 0.3 |
| **#1 Plastic** | 23.3 | 1.5 |
| **#2 Plastic** | 19.1 | 1.2 |
| **#5 Plastic** | 17.0 | 1.1 |
| **#6 Plastic** | 33.9 | 2.2 |
| **Hard Plastic** | 55.1 | 3.6 |
| **Newspaper** | 12.7 | 0.8 |
| **Food Waste** | 125.1 | 8.1 |
| **Cans** | 4.2 | 0.3 |
| **Scrap Metal** | 2.1 | 0.1 |
| **OR Wrap** | 27.6 | 1.8 |
| **Electronics** | 1.1 | 0.1 |
| **Confidential Documents** | 1.1 | 0.1 |
| **Examination Gloves** | 95.4 | 6.2 |
| **Diapers** | 390.1 | 25.2 |
| **Food Wrappers** | 19.1 | 1.2 |
| **Paper towels** | 201.4 | 13.0 |
| **Rubber** | 4.2 | 0.3 |
| **Soft Plastic** | 176.0 | 11.4 |
| **Blood-Containing Waste** | 12.7 | 0.8 |
| **Textiles** | 38.2 | 2.5 |
| **IV Bags and Tubing** | 108.1 | 7.0 |
| **Wood** | 0.0 | 0.0 |
| **Styrofoam** | 14.8 | 1.0 |
| **Disposable Hospital Wear** | 46.6 | 3.0 |
| **Total** | **1548.7 kg** | **100%** |

As shown in Table 2, 28.5% of the waste sorted during the hospital's 2013 audit consisted of divertible materials. In 2012, 50.5% of the audited waste was divertible. This is a 22% reduction in improperly landfilled recyclable waste.

The implementation of blue wrap recycling and composting has led to a significant decrease in the amount of blue wrap and food waste found in the landfilled waste stream. The promotion of traditional recycling has led to a decrease in the amount of recyclable paper and plastic products being sent to landfill. During the 2012 waste audit, approximately 70% of the #5 plastic uncovered in the waste consisted of bedpans and urinals. Following the installation of automated bedpan flushers, no bedpans or urinals were found in the waste during the 2013 audit.

### 4.4 ISSUES SPECIFIC TO HOSPITAL WASTE AUDITS

O. Reg. 102/94 also requires hotels, retail shopping establishments, educational institutions, manufacturing facilities, and restaurants to conduct annual waste audits. However, extra precautions must be taken when performing hospital waste audits. The waste from healthcare facilities has the potential to be far more dangerous than waste generated at other types of facilities (International Committee of the Red Cross, 2011). For example, hospital waste can potentially include used needles, blood, feces, vomit, medications/narcotics, and infectious waste (i.e. a tongue depressor used in the mouth of a patient with influenza). These risks are generally not identified in wastes from education institutions, hotels, retail shopping centers, etc. As a result, it is important that sufficient personal protective equipment is worn for hospital waste audits. The auditor donned a hazmat suit, puncture-resistant gloves, shoe covers, eye protection, and a mask to ensure that cross-infection would not occur. All waste was handled extremely carefully and slowly to prevent an accidental needle-stick injury.

Patient confidentiality is another factor that is unique to hospital waste auditing. According to the Ontario Personal Health Information Protection Act (2004), all documents containing personal health information (any information that could identify the patient) must be destroyed before disposal. The test hospital employs a company to remove all confidential documents to a secure location before shredding and recycling the files. However, it is unrealistic to expect that 100% of the hospital's confidential documents are sent for shredding. Human error is an ever-present possibility (Reason, 2000), so when staff have the option to place confidential documents in either the shredding receptacle or the waste/recycle bin, it is inevitable that some documents will be disposed of incorrectly. This creates the opportunity for confidential documents to be captured in the trash. It is essential that a hospital waste auditor maintain the confidentiality of sensitive documents that may be uncovered during the audit. At no time should the names, conditions, or treatments of patients be discussed with any party.

## 4.5 COMPOSTING

The hospital purchased two Food Cycler 250 in-vessel composters from Food Cycle Science, as seen in Figure 13. Each unit is capable of converting 250 pounds of food waste to sterile fertilizer daily.

**Figure 13: Food Cycler 250**

The rule of thumb for what can be processed by the composters is "If you can eat it, the Food Cycler can eat it." This means that all of the uneaten food that returns to the kitchen on patient trays, as well as the kitchen's food preparation scraps and leftovers from the cafeteria's salad bar, are diverted from landfill each day.

Each composter is equipped with a motor that spins 6 paddles within the unit chamber. A heating element raises the chamber temperature to 82ºC. The churning action of the paddles, along with the high temperature, dehydrates the food waste and pushes the excess water out through a drain. The process time for a Food Cycler 250 is 15 hours (the hospital runs the units overnight). The end result is a sterile, nutrient-rich organic fertilizer that is being donated to a local non-profit organization which grows produce for the city's underprivileged residents. The units provide a mass reduction of 90% (250 pounds of food waste will yield 25 pounds of fertilizer).

Figure 14 shows a composter full of food waste (prior to cycle), a unit containing the end product (after the cycle), and the sterile fertilizer discharging from the machine for collection.

Before Cycle: Food Waste | After Cycle: Sterile Fertilizer | By-product Discharging From Unit

**Figure 14: Composting Process**

In total, 500 pounds of food waste (patient tray, kitchen, and cafeteria leftovers) is diverted from landfill each day (the units are filled to capacity). However, any food scraps that employees may have from their lunches in offices, break rooms, the cafeteria, etc. are not captured by composting and will go to landfill. It was originally estimated that the kitchen food waste would not be enough to fill the units, and organics collection bins would be placed throughout the hospital. However, the composters are filled to capacity each day with only the food waste generated in the Dietary department – it was not possible to compost food waste from other areas.

Five hundred pounds of food waste diverted from landfill daily amounts to nearly 83 tonnes per year. Waste haulage is charged by weight (as well as by the number of pickups). Food waste is the heaviest component of the hospital's solid waste stream, and by diverting 83 tonnes of food waste per year, the hospital will realize significant cost savings associated with landfilled waste.

According to calculations from the hospital's 2012 waste audit, the waste compactor is emptied when it contains approximately 6.9 tonnes of refuse. Therefore:

Number of Pickups for Food Waste = (83 tonnes/year) / (6.9 tonnes/pickup)
= 12 pickups

Cost Savings from Diverting 83 tonnes/year = [(83 tonnes) x ($34.92/tonne)] +
[(12 pickups) x ($63.05/pickup)]
= $3,654.96 /year

The composters have also replaced the kitchen's pulper, which previously mulched up the department's food waste before segregating it into bags for disposal to landfill. The annual cost for parts to maintain the pulper is $783.26, and the annual cost to unclog the pulper drain is $2,100. Therefore:

Annual Labor Cost Savings from Eliminating Pulper = $783.26 + $2,100
= $2,883.26 /year

The energy and water usage of the two combined composters versus the pulper is summarized in Table 3, below:

**Table 3: Comparison of Composter and Pulper Energy and Water Usage**

| | **Two Composters** | **Pulper** |
|---|---|---|
| **Energy Usage (kWh/day)** | 6.0 | 25.6 |
| **Water Usage (gallon/day)** | 0 | 18 |

The hospital currently pays $0.075/kWh, and $0.0025/gallon of water. Table 4 highlights the operational costs of the composters and the kitchen's pulper.

**Table 4: Comparison of Composter and Pulper Operational Costs**

| | **Two Composters** | **Pulper** |
|---|---|---|
| **Energy Cost per Day** | (6 kWh) x ($0.075/kWh) = $0.45 /day | (25.6 kWh) x ($0.075/kWh) = $1.92 /day |
| **Water Cost per Day** | (0 gal) x ($0.0025/gal) = $0 /day | (18 gal) x ($0.0025/gal) = $0.045 /day |
| **Energy Cost per Year** | ($0.45/day) x (365 days/year) = $164.25 /year | ($1.92/day) x (365 days/year) = $700.80 /year |
| **Water Cost per Year** | ($0 /day) x (365 days/year) = $0 /year | ($0.045/day) x (365 days/year) = $16.43/year |
| **Total Operational Cost Per Year (Energy + Water)** | **$164.25 /year** | **$717.23 /year** |

Therefore:

Annual Operational Savings from Replacing Pulper with Composters
= $717.23 - $164.25
= $552.98 /year

**Total Annual Cost Savings from Implementing Composting**

= Cost Saved from Diverting Food Waste from Landfill + Cost Saved by Eliminating Pulper + Operational Cost Savings
= $3,654.96 + $2,883.26 + $552.98
= **$7,091.20/year**

These cost estimates are based on the current waste hauling cost per tonne, the previous year's costs associated with the kitchen's pulper, and the hospital's current water and electricity costs. These prices are subject to change, but it is shown that composting will lead to an overall operational cost savings.

Each composter cost $27,500.00, for a total of $55,000. These units were purchased with the funding provided by the OHA.

## 4.6 BIOHAZARDOUS WASTE MANAGEMENT

Beyond the generation of municipal solid waste, hospitals produce a significant amount of biohazardous/toxic waste that must be segregated and handled to protect the health and safety of hospital employees, patients, and the public. Pharmaceuticals (medications), biomedical (infectious) waste, human waste, and chemicals must all be handled appropriately to prevent improper disposal.

### 4.6.1 Reusable Pharmaceutical Containers

Unused medications must be securely disposed of in an impenetrable pharmaceutical container to prevent them from illegal or inappropriate use (narcotics are often used in a hospital setting). Prior to the research, the hospital's plastic pharmaceutical containers were incinerated along with their contents. Reusable pharmaceutical containers (as shown in Figure 15) have been purchased to replace the disposable variety throughout the hospital. When the new containers are full, the contents are incinerated and the container is sterilized and returned for reuse. The pharmaceutical containers are currently in stock at the hospital, and are awaiting installation.

**Figure 15: Reusable Pharmaceutical Container**
Image From Daniels International

The test hospital currently utilizes forty-eight 14-liter and three 22-liter disposable pharmaceutical containers (a total of 51 containers). The hospital pays $13.75 per disposable container, which are exchanged 12 times per year (once per month). Therefore:

Current Annual Cost for Disposable Pharmaceutical Containers
= (51 containers) x ($13.75/container exchange) x (12 exchanges/year)
= $8,415/year

The new reusable pharmaceutical containers will be removed at a charge of $10.50 per exchange of the forty-eight 14-liter containers, and $21.75 per exchange of the three 22-liter containers. Therefore:

New Annual Cost of Reusable Pharmaceutical Containers
= [(3 containers) x ($21.75/container exchange) x (12 exchanges/year)] +
[(48 containers) x ($10.50/container exchange) + (12 exchanges/year)]
= $6,831/year

Annual Savings from Switching to Reusable Pharmaceutical Containers
= Annual Cost of Disposable Containers – Annual Cost of Reusable Containers
= $8,415.00 - $6,831.00
= **$1,584.00 /year**

Switching to reusable pharmaceutical containers will prevent the incineration of 612 plastic containers annually (51 containers exchanged 12 times per year), and will eliminate the consumption of plastic resources associated with medication disposal.

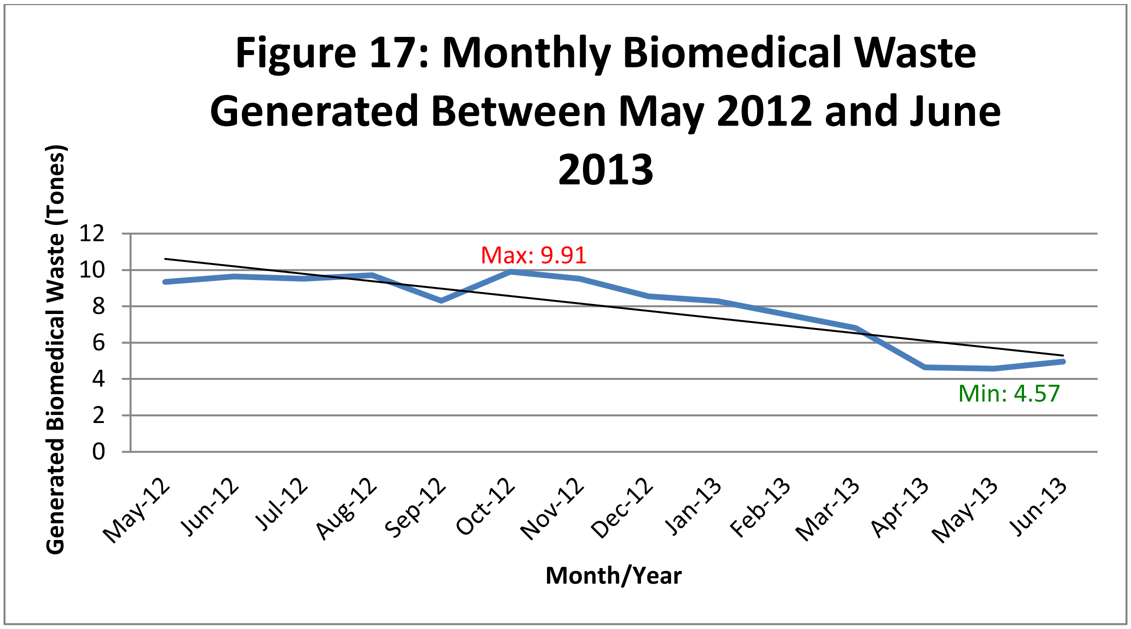
### 4.6.2 Bagless Biomedical Waste Containers

On regular nursing units (with patient beds), biomedical waste is an infrequent occurrence and is well controlled: there is a single biomedical waste bin for each unit, and biomedical waste is discarded there as needed. However, in the hospital's 26-station dialysis unit, there were no waste or recycling bins, only 26 (one per chair) open-top bins lined with yellow biomedical waste bags. All waste went into the biomedical waste stream, regardless if it was truly biomedical waste or not. The yellow bags were removed from the bins and sent for incineration (the hospital was incinerating over 16,000 plastic bags annually). Biomedical waste is 14 times more expensive for the hospital to dispose of than regular waste: biomedical waste is removed for $0.49 per kilogram, and regular waste is removed for $34.94 per tonne, or $0.035 per kilogram, and recycling is free for the test hospital. It was necessary to control what was being disposed of in the biomedical waste bins so all refuse could be dealt with appropriately. Non-hazardous plastics, paper, metal, glass, and other waste should not be treated as biomedical waste.

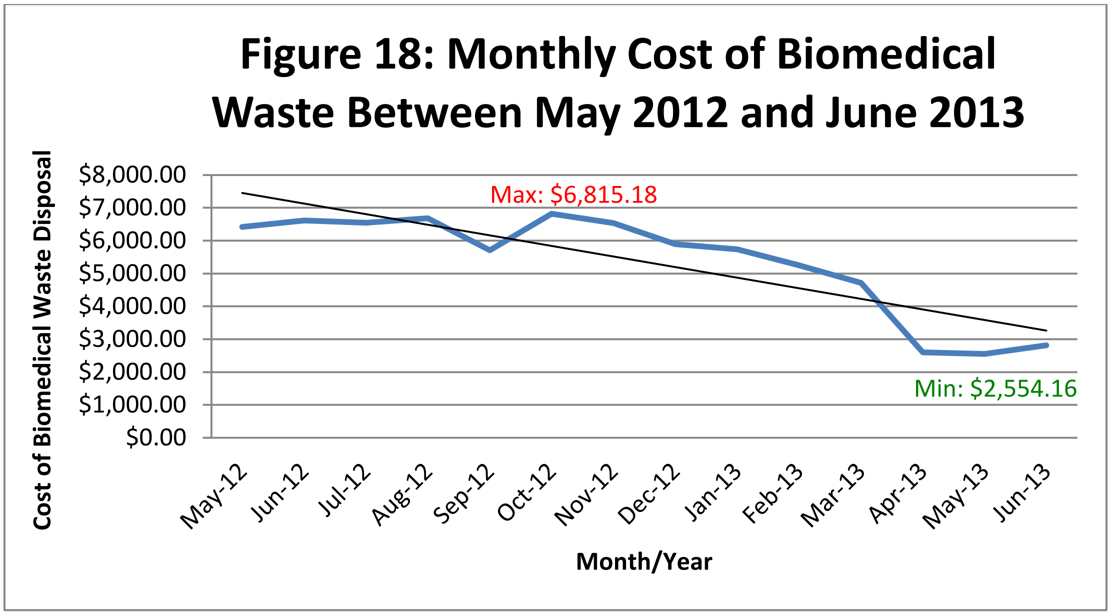
All 26 open-top biomedical waste bins were removed, and 9 bagless biomedical waste containers (one for every 3 dialysis chairs), along with regular waste and recycling bins were implemented. The new biomedical waste containers (as shown in Figure 16) have a foot pedal, and the manual input required to lift the lid was hypothesized to act as a deterrent to putting all waste into the biomedical waste stream, and to instead encourage more discretion in disposal. By having fewer biomedical waste bins available and providing regular waste and recycling bins, waste is now more appropriately sorted. When the bagless biomedical waste containers are full, the contents are incinerated and the container is sterilized and returned for reuse. As a result, thousands of plastic bags are saved from use and incineration annually.


**Figure 16: Bagless Biomedical Waste Container**

In addition to switching bin types to help control the appropriate segregation of biomedical waste, a comprehensive hospital-wide information initiative was launched to provide information on what is and is not considered biomedical waste. The Ontario Ministry of the Environment defines biomedical waste as items that are saturated with blood, or items that have been contaminated in any capacity with infectious blood (hepatitis, HIV, etc.). Healthcare providers are often under the impression that any item that comes into contact with patients (thermometer cover, gloves, etc.) has to be considered biomedical waste, as they could be contaminated with pathogens (James, 2010). Biomedical waste deals with blood waste only, and does not require all patient-contacted items to be incinerated. The hospital-wide information initiative, coupled with the introduction of a controlled disposal system, has led to a significant decrease in the amount of biomedical waste generated by the test hospital, as shown Figure 17.




Prior to the research, the hospital was partnered with a biomedical waste provider which charged $630 per tonne of biomedical waste generated. In April 2013, the hospital's contract with this vendor expired, and the organization entered into a contract with a new biomedical waste provider in order to implement the bagless biomedical waste containers (they are unique to this company). The new vendor charges $490 per tonne of biomedical waste generated. This reduction in price, coupled with the marked decrease in generated biomedical waste, has led to a significant reduction in biomedical waste removal costs, as shown in Figure 18.




**4.6.3 Automated Bedpan Flushers**

Prior to the research, the test hospital was equipped with hopper systems (large sinks) to clean soiled bedpans and urinals, as shown in Figure 19. These systems have been proven to splatter the contents of the bedpans and urinals while rinsing them (Gerba et al, 1975). Figure 20 shows the degree of fecal contamination found in hopper systems. This is a significant infection control issue that can be addressed by implementing automated bedpan flushers.

**Figure 19: Hopper System (Spray)**
Image from fredericksburg.com

**Figure 20: Hopper Fecal Contamination**
Image from webbertraining.com

There is also a major environmental/waste management component that bedpan flushers can address. The hospital's previous policy was for nurses to rinse soiled bedpans and urinals in the hoppers, and then send them down to the Central Sterile Reprocessing Department (CSR) to be sterilized. Instead of using what were perceived as "unsanitary" hoppers, soiled bedpans/urinals were often either thrown in the trash or sent to CSR for sterilization filled with waste. When CSR employees received a full bedpan or urinal, they disposed of it in the trash instead of removing the waste by hand before sending it through the sterilizer. In summary, if a bedpan/urinal was not rinsed in a hopper, it was sent to landfill.

The hospital has purchased 13 Typhoon bedpan flushers from ArjoHuntleigh (Figure 21) in an attempt to eliminate this wasteful practice. The Typhoon units have sensor-operated doors, to eliminate the need for manual opening and closing. Fully soiled items (bedpans, urinals, k-basins, commode pots, etc.) are placed onto the flusher racks, which tip the items upside down to empty their contents. No human waste is manually handled. Items are blasted with water and detergent to remove soil, and disinfection is achieved through steam heat (95 ºC). Each cycle runs for 7-10 minutes (depending on how soiled the items are), and uses an average of 24 liters of water. Following disinfection, the items are dried and cooled, and are available for immediate reuse.

**Figure 21: Typhoon Bedpan Flusher**
Image from ArjoHuntleigh

The hospital was periodically using plastic bags to line their bedpans and commode pots to reduce the amount of waste that must be handled by employees. These bags collected human waste, and were then disposed in the trash, leaving a visibly "clean" bedpan, which then went either back to the patient or to CSR for sterilization. In the former case, this is an infection control issue – bedpans must be disinfected after each patient use; in the latter case, there was wastage because of redundant protection measures.

The hospital used 200 boxes of bedpan liners per year. Each box costs $20.12.

Annual Cost of Bedpan Liners = (200 boxes) x ($20.12 /box) = $4,024/year

Not only was the hospital purchasing bedpan liners, but they also had to pay for their disposal to landfill:

Annual Weight of Bedpan Liners = (200 boxes)x(20 bags/box)x(1 lb/bag)x(1 kg/2.2 lb)
= 1,818.18 kg x (1 tonne/1000 kg)
= 1.82 tonnes

The weight of a used bedpan liner was taken to be 1 pound, as the average human stool weighs 1 pound (Newcomer, 2012).

Number of Bedpan Liner Pickups = (1.82 tonnes bedpan liners) / (6.89 tonnes/pickup)
= 0.26 pickups

Annual Cost to Landfill Bedpan Liners = [(0.26 pickups) x ($63.05/pickup)] +
[(1.82 tonnes) x ($34.92/tonne)]
= $79.95 /year

Due to staff throwing reusable bedpans and urinals in the trash, the hospital must purchase replacement items. The hospital purchased 666 bedpans and 2212 urinals the previous year to replace items sent to landfill.

Annual Bedpan Replacement Cost = (666 bedpans) x ($10.70/bedpan) = $7,126.20/year

Annual Urinal Replacement Cost = (2212 urinals) x ($4.06/urinal) = $8,980.72/year

The test hospital must pay to send their disposed bedpans and urinals to the landfill. According to the 2012 waste audit, the hospital disposes 10.51 tonnes of #5 plastic each year. Based on visual observation while sorting the waste for the audit, it was estimated that 70% of the #5 plastic (by weight) was either bedpans or urinals.

Annual Weight of Disposed Bedpans/Urinals = (10.51 tonnes) x (0.7) = 7.36 tonnes

Number of Bedpan/Urinal Pickups = (7.36 tonnes) / (6.89 tonnes/pickup) = 1.07 pickups

Annual Cost to Landfill Bedpans/Urinals = [(1.07 pickups) x ($63.05/pickup)] +
[(7.36 tonnes) x ($34.92/tonne)]
= $324.47/year

Table 5 compares the energy and water usage and costs associated with the automated bedpan flushers versus the current CSR sterilizer.

**Table 5: Comparison of Automated Bedpan Flusher and CSR Sterilizer Energy and Water Usage**

| | **Automated Flusher** | **CSR Sterilizer** |
|---|---|---|
| **# of Bedpans/ Urinals Cleaned per Cycle** | 2 bedpans/4 urinals | 8 bedpans/16 urinals |
| **Energy Use per Cycle** | 0.25 kWh | 16.8 kWh |
| **Water Use per Cycle** | 30 L | 143 L |

As seen in the above chart, the CSR sterilizer is capable of cleaning 4 times more bedpans/urinals per cycle than the automated flusher system. Since each unit will have their own bedpan flusher, this smaller capacity will not have a negative effect on the availability of clean bedpans/urinals. CSR washes the combined bedpans/urinals from each unit daily during a specific time frame, so their sterilizer must have a larger capacity. When each unit has their own flusher, the limited capacity will not be an issue, as far fewer bedpans/urinals must be washed in a day, and bedpans/urinals will be used and washed sporadically throughout the entire day/night.

For the purpose of this comparison, the energy and water use per automated flusher cycle will be multiplied by 4 so that the evaluation of each system is for an equal number of bedpans/urinals washed. The test hospital currently pays $0.0006 per liter of water, and $0.075 per kWh. Table 6 compares the operational costs of the automated bedpan flushers and the CSR sterilizer.

**Table 6: Comparison of Automated Bedpan Flusher and CSR Sterilizer Operational Costs**

| | Automated Bedpan Flusher | CSR Sterilizer |
|---|---|---|
| **Energy Cost per Cycle** | (0.25 kWh) x (4) x ($0.075/kWh) = **$0.0792 /cycle** | (16.8 kWh) x ($0.075/kWh) = **$0.09438 /cycle** |
| **Water Cost per Cycle** | (30 L) x (4) x ($0.00066/L) = **$0.075 /cycle** | (143 L) x ($0.00066/L) = **$1.26 /cycle** |

As shown in Table 6, the automated flusher system uses less water and energy than the CSR sterilizer, and therefore costs less to operate.

**Annual Cost Savings from Implementing Typhoon Bedpan Flushers**
= Annual Cost to Purchase Bedpan Liners + Annual Cost to Landfill Bedpan Liners + Annual Cost to Purchase Replacement Bedpans + Annual Cost to Purchase Replacement Urinals + Annual Cost to Landfill Bedpans and Urinals
= $4,024.00 + $75.95 + $7,126.20 + $8,980.72 + $324.47
**= $20,531.34/year** (+ savings from operational cost of flushers vs. CSR sterilizer)

These cost estimates are based on the previous year's number of purchased bedpan liners and replacement bedpans and urinals, the amount of bedpans/urinals uncovered in the trash in the 2012 waste audit, the current water and electricity costs, and the current waste hauling cost per tonne. These costs are subject to change, but implementing automated bedpan flushers will lead to an overall operational cost savings.

Each bedpan flusher cost $15,450.00, for a total of $200,850.00. These units were purchased with the funding provided by the OHA, and have significantly reduced the possibility of fecal contamination of healthcare providers and patients alike.

### 4.6.4 Aqueous Ozone Cleaning Solution

At the onset of the research, the test hospital used a wide variety of harsh chemicals to disinfect all areas of the facility. Aqueous ozone has been proven to be a natural disinfectant that kills bacteria and viruses, contains zero toxins or irritants (Zuma et. al., 2009), and remains stable and effective at achieving disinfection for 24 hours after it is dispensed.

Twenty-five LotusPro aqueous ozone dispensers (Figure 22) were purchased from Eau3 Distributing Inc., and installed in each of the hospital's housekeeping closets. Currently, aqueous ozone is approved by Health Canada for use on all surfaces in non-patient care areas (offices, hallways, public washrooms, elevators, waiting rooms, etc.) and floors in patient rooms. The hospital has been able to completely eliminate the use of chemicals in public areas, and has eradicated the chemical that was previously used on floors.

**Figure 22: LotusPro Aqueous Ozone Dispenser**
Image from Eau3 Distributing Inc.

Figure 23 describes how aqueous ozone is generated, as well as how it achieves sanitization.

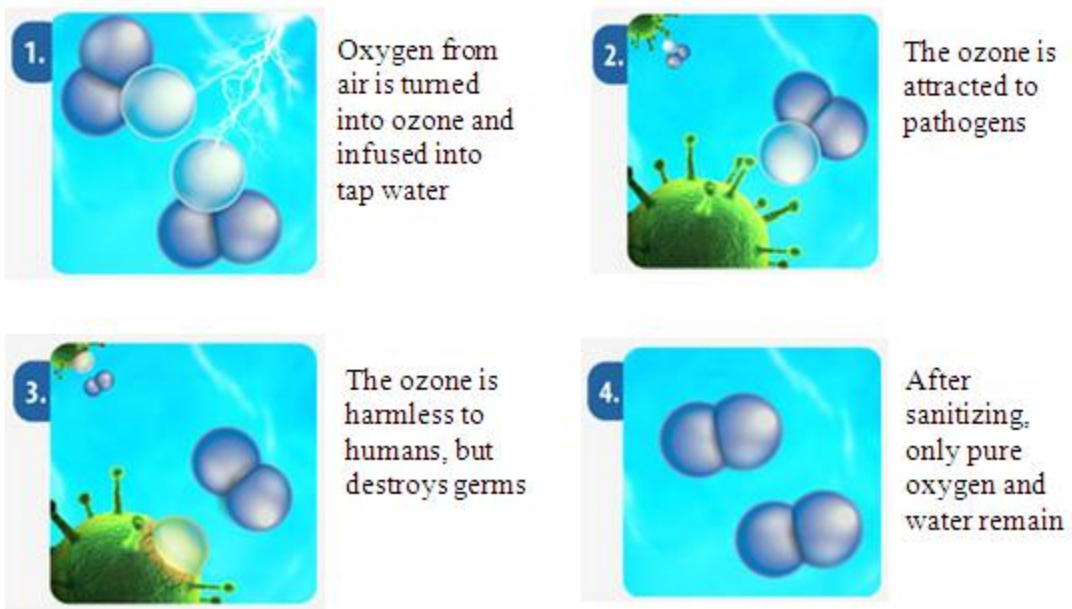



**Figure 23: How Aqueous Ozone is Created and Sanitizing Process**
Image from Eau3 Distributing Inc.

Controlling hospital-acquired infections is greatly important in the healthcare industry (National Audit Office, 2000). Aqueous ozone has been proven to destroy several bacteria and viruses, including *Clostridium difficile (C. diff)*, *Methicillin-Resistant Staphylococcus Aureus (MRSA), Norovirus, Influenza, Hepatitis A, Escherichia Coli (E. coli),* and *Salmonella* (Lotus Pro, 2009).

Full Health Canada approval for ozone use on all surfaces, including in patient rooms, will occur in the near future. At this time, the test hospital will eliminate the use of nearly all chemicals. As an additional benefit, the use of aqueous ozone can create a healthier work environment for housekeepers by avoiding toxic off gases, and can improve indoor air quality for patients.  Furthermore, by significantly reducing the use of chemicals, there will be fewer plastic bottles, dispensers, and cardboard boxes produced that have to be handled, recycled, or disposed. Table 7 highlights the amount of chemical solution that the test hospital uses per year that can currently be replaced with aqueous ozone. The solution is currently not approved for use on high-touch surfaces in patient rooms; there are some chemicals that must remain in use until full Health Canada approval is given.

**Table 7: Cleaning Chemicals Currently Replaced with Ozone**

| Solution | # of Bottles/ Year | Volume per Bottle | Total Volume/ Year | Cost Per Bottle | Total Cost/Year |
|---|---|---|---|---|---|
| **BreakUp** (degreaser) | 42 | 2.5 L (dilute 1:60) | 42 x 2.5 x 60 = 6,300 L | $35.64 | 42 x $35.64 = $1,496.88 |
| **Glance** (glass cleaner) | 8 | 2.5 L (dilute 1:40) | 8 x 2.5 x 40 = 800 L | $30.77 | 8 x $30.77 = $246.16 |
| **Stride** (floor cleaner) | 40 | 2.5 L (dilute 1:256) | 2.5 x 40 x 256 = 25,600 L | $62.36 | 40 x $62.36 = $2,494.40 |
| **Kleen + Shine** (stone floor cleaner) | 132 | 0.946 L | 132 x 0.946 = 124.87 L | $1.47 | 132 x $1.47 = $194.04 |
| **Drackett** (removes salt from floors in winter) | 26 | 90 pods (11 L per pod) | 26 x 90 x 11 = 25,740 L | $40.10 | 26 x $40.10 = $1,042.60 |
| | | | **Total = 58,564.87 L = 15,472.84 gal** | | **Total = $5,474.08** |

The hospital uses approximately 15,473 gallons of chemical cleaning solution every year in areas in which aqueous ozone can be used (all except high-touch patient areas). These chemicals, totaling nearly 15,473 gallons, cost the hospital $5,474.08 per year. The cost comparison of aqueous ozone and traditional chemicals will be based on 15,473 gallons of solution.

Annual Cost of Purchasing Chemicals = $5,474.08/year

The ozone dispensers require stabilizers, which convert tap water to aqueous ozone. These stabilizers cost $135 each, and must be replaced every 1,600 gallons of dispensed solution. Therefore, if we use 15,473 gallons of ozone solution, we will have to replace the stabilizer 10 times (15,473 gallons / 1,600 gallons = 9.67 ≈ 10 replacements). Therefore:

Annual Cost of Purchasing Stabilizers = (10 replacements) x ($135/replacement)
= $1,350.00/year

**Annual Cost Savings from Implementing Ozone Solution**
= Savings from Eliminating Chemical Purchases – Cost to Purchase Stabilizers
= $5,474.08 - $1,350.00
**= $4,124.08 /year**

These cost estimates are based on the previous year's volume of purchased replaceable chemicals and the equivalent number of required stabilizers. These volumes are subject to change, but it is shown that the implementation of aqueous ozone cleaning solution will lead to an overall operational cost savings. Stabilizers are less expensive than chemicals, and soon the hospital will be approved to use ozone on all surfaces, completely eliminating the need for chemicals.

Each LotusPro dispenser cost $2,600, for a total of $65,000.00. These units were purchased with the funding provided by the OHA, and have already made a noticeable improvement in the visible cleanliness of the hospital (chemicals leave sticky residues that collect dust and dirt, while aqueous ozone does not).

## 4.7 HOSPITAL ENVIRONMENTAL MANAGEMENT FRAMEWORK

The HEMF illustrated in Figure 4 was used to implement and ensure the success of several waste management initiatives. The environmental statement and policy were essential in setting the expectations for organization-wide participation and commitment to improved environmental performance.

The planning stage included a waste audit to establish the baseline waste composition. This determined what percentage of the hospital's landfilled waste stream could in fact be diverted, and identified which divertible materials were most prevalent in the waste. An environmental review of the hospital led to a better understanding of which departments required interventions. Non-ideal waste management practices were observed and later rectified.

The implementation phase included the installation of various equipment to facilitate the hospital's advancement in the environmental field. It was necessary to draw on new technology to maximize the hospital's progress toward sustainability. Policies and procedures were developed to communicate the hospital's commitment to, and need for staff participation in, all new environmental initiatives.

Following the implementation of the various initiatives, it was necessary to measure their success in reducing waste sent to landfill. The hospital's waste hauling records and invoices from the research period were studied to verify the impact of the organization’s waste reduction efforts. A significant reduction in landfilled waste was achieved. In the 2012-2013 fiscal year, the hospital sent 70 fewer tonnes of waste to landfill than during the 2011-2012 fiscal year. A second waste audit was performed to determine the improved waste composition resulting from the newly-implemented environmental initiatives. There was a 22% reduction in divertible waste inappropriately sent to landfill, indicating that the EMS initiatives were successful.

Management was involved from the beginning of the project. While management review is an essential concluding phase (to confirm that efforts will continue to be upheld and enforced), it was vital to have executive approval during each step of the EMS implementation to ensure the success of the initiatives. If management is not satisfied with an initiative, it will not be implemented or sustained in a productive manner.

Proper waste disposal among hospitals has traditionally been a neglected practice (Tsakona et al, 2007). However, many hospitals are now working toward controlling their waste (Ogden, 2009), but are not utilizing a formal framework to do so. While initiatives can be implemented without the use of an HEMF, they are less likely to succeed over time, as an HEMF continuously monitors the progress of efforts and aims to constantly improve upon environmental performance.

An HEMF is a highly comprehensive framework for controlling and improving environmental performance. The implementation of an HEMF requires the oversight and attention of a dedicated employee. Hospitals often do not employ a position responsible for waste management or environmental performance. The responsibility of waste management often lies with the Environmental Services department, whose main focus and responsibility is to clean and disinfect the patient environment to prevent the spread of infection (Barlow, 2012). Patient safety and avoiding hospital-acquired infections takes precedence over waste management. With no designated employee responsible for waste management or environmental performance, the Environmental Services team's time is monopolized by hospital disinfection practices.

According to Munoz (2012), it is well documented that mismanaged hospital waste has the potential to harm the environment. There are several articles published on what initiatives hospitals can undertake in order to improve their waste management (blue wrap recycling, proper biomedical waste segregation, etc.). However, there is a lack of literature on the methods needed to actually implement these changes. This research serves to educate healthcare leaders on how to successfully implement waste management initiatives with proven results. Policies and procedures are needed to ensure new practices are followed correctly at every opportunity. The success of the initiatives must be determined in order to quantify the associated waste management improvements or identify areas requiring further attention. Management must review the initiatives to gauge their effectiveness and feasibility within the healthcare organization. In order to ensure waste management success, the HEMF must be observed: it is insufficient to simply set a project into action and let it run its course.

## 4.8 NEXT STEPS IN HEMF IMPLEMENTATION AT THE TEST HOSPITAL

One of the most difficult industries in which to create change is the healthcare industry (Domingo, 2003). Significant, time-consuming approvals processes are in place to govern change. As a result, implementation of new initiatives is a slow-moving process. The research has already led to a significant reduction in landfilled waste, but more progress is imminent.

### 4.8.1 Installation of Reusable Pharmaceutical Containers

The hospital's reusable pharmaceutical containers are currently in stock, and have been installed in three nursing units (pharmaceutical containers are mounted and locked to the walls so they are not able to be stolen). The remaining pharmaceutical containers will soon be installed, which will mark the completion of this initiative.

### 4.8.2 Continued Automated Bedpan Flusher Installation, Training, and Use

Currently, 8 of the 13 automated bedpan flushers have been installed. The hospital's Professional Practice Leaders (nurse educators), along with the Infection Prevention and Control Manager, are in the process of training healthcare providers on the proper use of the flushers. Installation of the flushers will continue until all 13 units are in operation. Training will be offered until all affected staff members have been educated on how to use the new technology, at which time all automated flushers will be permanently in use and soiled bedpans/urinals will cease to be manually cleaned.

### 4.8.3 Styrofoam Elimination

The test hospital uses Styrofoam products in three operations: the coffee bar (cups), the cafeteria (clamshell containers, bowls, and plates), and patient units (water pitchers and cups). Meetings were held with the hospital's kitchenware supplier, and it was determined that Styrofoam is the least expensive option for cups, containers, plates, and bowls. Disposable paper, plastic, or compostable items, all of which have end-of-life options other than landfill (recycling or composting), are considerably more expensive than the Styrofoam option. While it is a clear environmental issue (the hospital uses and landfills approximately 1.3 million Styrofoam items per year – see Appendix D), the test hospital does not currently have the budgetary capacity to increase their operating costs by completely eliminating Styrofoam.

However, one Styrofoam-replacement initiative will ideally form a trial run. Reusable plastic water pitchers are available for patient use, and may be tested on one nursing unit. Unlike the coffee bar and cafeteria, patient cups do not have to be disposable. These items do not leave the hospital, so they can be reused (washed). There would be an upfront capital expense to purchase enough water pitchers for each hospital bed, but the cost of purchasing Styrofoam pitchers and patient cups would be completely eliminated, which would result in immediate annual cost savings.

Twenty-ounce reusable plastic water pitchers are preferred to replace the patient Styrofoam pitchers and cups. Small cups would no longer be utilized, as straws would be placed in the pitchers (large lidded mugs) and the patients would drink directly from there. The test hospital has 340 beds, which will be rounded to 350 to account for patient overflow in the Emergency Department. To ensure that enough water pitchers would always be available, 700 would be ordered (double the bed amount). Each pitcher costs $5.57; therefore, 700 pitchers would come at a cost of $3,899. Although the reusable pitchers are being trialed on one unit, the presented cost analysis is for the entire hospital, to demonstrate the financial feasibility of organization-wide implementation.

Carts would need to be purchased (one-time cost) to transport the pitchers. Seven carts would be purchased, each at a price of $200.00, for a total amount of $1,400. According to purchase records, the hospital currently pays $31,391.25 per year for patient water cups and pitchers.

Total Cost of Reusable Water Pitchers and Carts = $3,899.00 + $1,400.00 = $5,299

Total Cost of Styrofoam Water Pitchers and Cups = $31, 391.25 /year

Initial Cost Savings from Switching to Reusable Pitchers = $31,391.25 - $5,299.00
= $26,092.25

There will likely be replacement costs (a number of patient pitchers will inevitably leave with patients upon discharge), but even if 100% of the pitchers and carts needed to be replaced each year, there would still be an annual cost savings of $26,092.25 when compared to the purchase and use of Styrofoam products. The anticipated plan is for kitchen staff to wash the patient water pitchers each night and place them on the carts. Hospital volunteers would collect the carts from the kitchen, fill them with water, and deliver them to patients. At the end of the day, the volunteers would collect the pitchers from the patient rooms and bring them back down to the kitchen to be washed.

This initiative would eliminate the Styrofoam used for patient water consumption. 706,250 Styrofoam items, weighing 3.42 tonnes, would be diverted from landfill annually. However, Styrofoam would still be used in the hospital lobby's coffee bar and cafeteria. The hospital has expressed interest in exploring all possibilities for replacing remaining Styrofoam items with an alternative material. However, the low cost of Styrofoam, compared to the higher cost of paper, plastic, or compostable items, will undoubtedly lead to difficulties in complete Styrofoam elimination.

#### 4.8.4 Single Stream Recycling

Currently, the hospital's recycling is provided by the City at no charge. However, they must separate their plastic, metal, and glass from their paper. While this is a common household practice, it is less ideal in a hectic hospital setting. While performing an operation or rendering intensive care, it is not always feasible to source separate recyclables. If all recyclable items were able to be disposed of in a single bin, far more items would be recovered for recycling. When sorting is not an option, hospital employees discard waste in the trash.

The hospital has been in contact with a local vendor who offers single-stream recycling. All plastic, metal, glass, and paper items can be discarded in the same bin. Bags of mixed recyclables would then be loaded into a 40 cubic yard compactor. The vendor employs workers to sort the recyclables in a warehouse. The cost for single-stream recycling is $85 per compactor lift, and the hospital would be given a rebate of $20 per tonne. The vendor would accept plastic bags and other items that the hospital cannot currently recycle with the City.

The hospital's cardboard compactor is also 40 cubic yards. Based on the previous year's service log, the average weight of the compactor contents per lift (when the compactor is full) was 2.6 tonnes. The hospital is currently recycling 7.5 tonnes per month, but it is estimated that this amount will rise to 10 tonnes per month when more items can be recycled and materials do not have to be sorted.

Number of Recycling Compactor Lifts per Month = 10 tonnes / (2.6 tonnes/lift)
= 3.8 ~ 4 lifts

Monthly Cost For Mixed Recyclables Removal
= ($85/lift)(4 lifts) – ($20/tonne)(10 tonnes)
= $140 /month

The hospital is currently recycling at no charge, so an executive decision with top-level support must be made in order to move forward with single-stream recycling.

### 4.8.5 Ongoing Monitoring

Under Ontario Regulation 102/94, hospitals with more than 100 beds are required to perform a waste audit each year. The test hospital's 2011-2012 and 2012-2013 waste audits were performed as part of the research. It is important that waste audits continue to be performed in the future, and are scrutinized to determine the extent of the ongoing waste reduction associated with the implementation of the HEMF.

### 4.8.6 Continued Development of the HEMF

In effect, the initial success of the HEMF can be measured by the success of its individual initiatives. However, the HEMF is ultimately greater than the sum of its parts. Achieved waste reduction is one facet of HEMF success, but there are several other measurable aspects. An established HEMF will ensure that the hospital is consistently compliant with regulations, and will provide the organization with the ability to easily adapt to regulatory changes.

It would be beneficial to implement a formal environmental education program for staff members. Employees should be able to recognize environmental issues and bring them to the attention of management in order for them to be addressed. Furthermore, if staff members are aware of the consequences of negative environmental performance, they will be more likely to participate in waste management initiatives (Munoz, 2012).

It would also be important to create a formal feedback system to gather opinions of affected employees and management. Incorporating the opinions and responses of frontline staff will ensure the longevity of the HEMF.

It would be beneficial for the hospital to set goals to continuously improve environmental performance (i.e. find only 20% divertible items in the 2013/2014 waste audit, maintain a monthly landfilled amount of less than 50 tonnes throughout the 2013/2014 year, etc.). Setting tangible goals will assist the organization in its quest for continued environmental improvement.

This research focused on waste management activities. However, there are other aspects of hospital operations that contribute to poor environmental performance. Water consumption, energy use, and air emissions also negatively impact the environment. It would be beneficial to eventually expand the HEMF to encompass these environmental impacts.

## 4.9 RECOMMENDATIONS FOR SUCCESSFUL IMPLEMENTATION OF HEMF IN HOSPITAL FACILITIES

In order for an HEMF to be successfully implemented in a complex acute care hospital, there is a pressing need for:

**1) Leadership buy-in to champion the project**

It is essential that hospital leadership be on-board with the HEMF to gain employee acceptance. Management attitudes are easily transcribed to employees, and a positive leadership outlook on the project is more likely to lead to successful outcomes (Goretsky, 2003).

**2) Employee buy-in to sustain the project**

It is important that hospital employees (nurses, housekeepers, food services workers, etc.) accept the HEMF in order to comply with new procedures. Without the full participation of affected employees, the project will not be successful (Goretsky, 2003).

**3) Environmental leadership position to design, coordinate, and oversee the project**

A formal, full-time position dedicated to environmental performance is needed to successfully oversee the HEMF. This position would draw on specialized skills, such as those from environmental engineering, to design, implement, and maintain an HEMF, as well as to address all of the hospital's environmental issues.

**4) Further research on how to approach this complex task in a complex environment**

More research into how to successfully implement an HEMF in a hospital setting is critical. According to Munoz (2012), there is substantial research on which initiatives can be implemented to reduce landfilled waste, but research is lacking on specific strategies useful in HEMF implementation. The research conducted here strongly supports these issues raised by Munoz (2012).

# CHAPTER 5

# CONCLUSION

## 5.1 CONCLUSION

The main objective of this research was to reduce the waste sent to landfill by a local test hospital by implementing a Hospital Environmental Management Framework (HEMF), which incorporates elements of an Environmental Management System, while going beyond the simple EMS framework to include step-by-step details on how viable initiatives were selected and implemented. Because the research undertaken involved actual hospital scenarios and circumstances, the summary and recommendations in the next two sections (5.1, 5.2) in fact form the basis for general recommendations for most hospital facilities and settings.

## 5.2 SUMMARY OF RESEARCH TASKS UNDERTAKEN

The following sub-objectives were met to complement the main objective:

1) The baseline composition of the hospital's landfilled waste was determined by performing a waste audit.

2) An environmental review was undertaken to determine which areas of the hospital generated the highest amount of preventable waste. These units were given top priority in waste management efforts.

3) Several waste management initiatives were implemented, including:

   a. Implementation of a Green Team

   b. Blue wrap recycling

c. Composting
d. Upgrade and promotion of traditional recycling
e. Reusable pharmaceutical containers
f. Bagless biomedical waste containers
g. Automated bedpan flushers
h. Aqueous ozone cleaning solution
i. Operating Room recycling

4) A second waste audit was performed to determine the altered composition of the hospital’s landfilled waste stream.

5) The waste removal invoices from the research period were reviewed to determine the amount of waste reduction and cost savings achieved by the implemented initiatives.

It was hypothesized that the test hospital would benefit from the implementation of an HEMF in the following ways:

1) Reduction in solid waste sent to landfill
2) Reduction of operational costs (removed waste is billed by weight; the less landfilled waste, the lower the cost)
3) Reduction in negative environmental impact

According to the hospital’s waste removal invoices, a significant reduction in landfilled waste was achieved. In June 2013, nearly 13.7 fewer tonnes were sent to landfill than in May 2012 when the research began. There was also a marked increase in the amount of waste being recycled by the facility. At the start of the research, 1.5 tonnes of waste were recycled each month, and the June 2013 recycling amount is up to 7.5 tonnes. As a result, landfilled waste removal costs are currently over $3,000 per month lower than what was paid at the commencement of the research.

The initial waste audit reviewed the waste removal invoices from April 2011-March 2012, revealing that the hospital sent 716.7 tonnes of waste to landfill during this period. The second waste audit reviewed the waste removal invoices from April 2012-March 2013, during which time the hospital sent 646.8 tonnes of waste to landfill. This is a reduction of 69.9 tonnes of waste sent to landfill from one fiscal year to the next. Given that there were no notable infrastructure or management changes during this time, this significant waste reduction can be attributed to the waste reduction initiatives implemented under the HEMF.

Comparing the first and second waste audits reveals an altered waste stream composition. Recyclables now comprise a smaller fraction of the hospital's landfilled waste. Fewer plastic and paper products were uncovered in the waste stream, and significantly less food waste and blue wrap were sent to landfill.

The end result is that of reduced landfilled waste and increased recycling, indicating that the HEMF was successful.

## 5.3 SUMMARY OF FURTHER RECOMMENDATIONS FOR TEST HOSPITAL

In order to finalize the implementation – and to ensure the ongoing success – of the HEMF, further action is required:

1) The remaining reusable pharmaceutical containers must be installed. All containers are in stock, and will soon be mounted on the walls of nursing units in the near future.

2) The remaining automated bedpan flushers must be installed, and staff must continue to be trained on the proper use of the units. Currently, 8 of the 13 flushers have been installed.

3) The elimination of Styrofoam must be investigated. Styrofoam generated in the cafeteria and coffee bar can potentially be replaced with recyclable paper or plastic items. However, Styrofoam is the least costly option, and any replacement will lead to an increase in purchasing costs. The potential for replacing Styrofoam patient cups with reusable plastic cups will be fully investigated.

4) The possibility of single-stream recycling must be addressed. The opportunity to discard all recyclable items into a single bin (without sorting) would significantly reduce the complexity of the hospital's recycling program and divert more waste from landfill. In some cases, the sorting process acts as a deterrent to proper waste segregation (in hectic situations, time is not available for sorting waste). However, there is a cost associated with this service, and the hospital currently recycles at no cost. An executive decision must be made on whether to proceed with single-stream recycling.

5) There must be ongoing monitoring of the HEMF to determine its continued performance and results. A waste audit must be performed each year to monitor the

percentage of recyclable items found in the landfilled waste stream. This will identify opportunities for waste management improvement.

6) The HEMF must be continually developed. It would be beneficial to implement formal feedback and staff education programs to take advantage of employee expertise. Future waste management goals and targets must be set to ensure continued improvement. Expanding the HEMF to include water usage, energy consumption, and air emissions will lead to a greater improvement in environmental performance.

7) Improved management and oversight is needed to implement a HEMF that can successfully improve a hospital's environmental performance. In addition to more, comprehensive research, this would require:

    1) Leadership buy-in to champion the project;
    2) Employee buy-in to sustain the project; and
    3) An environmental leadership position drawing from specialized skills such as those from environmental engineering to design, coordinate, and oversee the project.

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# APPENDICES

## APPENDIX A: Environmental Policy

### ENVIRONMENTAL POLICY

1. The primary focus of modern-day hospitals is to maintain the health of the population and aid the sick throughout recovery. It has been proven that environmental pollution leads to adverse health effects in the local population[1]. As an extension of in-house healthcare provided to hospital patients, we are committed to reducing our environmental impact in an effort to maintain a healthier population.

2. The organization will comply with all environmental regulations and legislature, in an effort to preserve environmental and human health, as well as to conserve resources.

3. The hospital will conduct a yearly waste audit to determine waste generation rates by category, as required under Ontario Regulation 102/94. This will allow the organization to focus on waste categories that require attention and action. The yearly waste audit will include an action plan, with detailed steps to improve environmental performance. This creates an opportunity for continuous improvement.

[1] Li, S., Williams, G., Jalalundin, B., & Baker, P. (2012). Panel Studies of Air Pollution on Children's Lung Function and Respiratory Symptoms: A Literature Review. *Journal of Asthma* 49 (9), 895-910.

**APPENDIX B: Environmental Statement**

## ENVIRONMENTAL PERFORMANCE STATEMENT

With the recent decision to implement a Hospital Environmental Management Framework (HEMF) to control our environmental performance, the organization has committed to reducing our landfilled waste, while increasing the amount of materials recycled.

In May 2012, a waste audit was conducted to determine the amount of waste sent to landfill by the facility annually. The results are summarized in the table below:

| Category of Waste | Weight of Category in 24-hr Sample (kg) | Percentage of Landfilled Waste |
|---|---|---|
| **Cardboard** | 72.0 | 4.2 |
| **Fine Paper** | 121.0 | 7.0 |
| **Glass** | 17.3 | 1.0 |
| **#1 Plastic** | 25.9 | 1.5 |
| **#2 Plastic** | 28.8 | 1.7 |
| **#5 Plastic** | 28.8 | 1.7 |
| **#6 Plastic** | 31.7 | 1.8 |
| **Hard Plastic** | 69.1 | 4.0 |
| **Newspaper** | 11.5 | 0.7 |
| **Food Waste** | 319.7 | 18.6 |
| **Cans** | 11.5 | 0.7 |
| **Scrap Metal** | 5.8 | 0.3 |
| **OR Wrap** | 118.1 | 6.9 |
| **Electronics** | 1.4 | 0.1 |
| **Confidential Documents** | 5.8 | 0.3 |
| **Examination Gloves** | 72.0 | 4.2 |
| **Diapers** | 57.6 | 3.4 |
| **Food Wrappers** | 11.5 | 0.7 |
| **Paper towels** | 141.1 | 8.2 |
| **Rubber** | 5.8 | 0.3 |
| **Soft Plastic** | 227.5 | 13.2 |
| **Blood-Containing Waste** | 37.4 | 2.2 |
| **Textiles** | 41.8 | 2.4 |
| **IV Bags and Tubing** | 195.8 | 11.4 |
| **Wood** | 1.4 | 0.1 |
| **Styrofoam** | 17.3 | 1.0 |
| **Disposable Hospital Wear** | 40.3 | 2.3 |
| **Total** | **1717.9 kg** | **100%** |

The waste categories highlighted in green represent materials that are divertible, and should not be sent to landfill. The 2012 waste audit determined that 50.5% of the hospital's waste sent to landfill was divertible.

Since the initial waste audit, we have undertaken several waste management initiatives in an effort to reduce the amount of waste sent to landfill, while increasing the rate of recycling at the facility, including:

- Formation of a Green Team
- Composting
- Blue Wrap Recycling
- Automated Bedpan Flushers
- Aqueous Ozone Cleaning Solution
- Upgrade of Traditional Recycling Program

In 2013, a second waste audit was conducted and significant improvement in waste management was observed, as summarized in the table below:

| Category of Waste | Weight of Category in 24-hr Sample (kg) | Percentage of Landfilled Waste |
|---|---|---|
| **Cardboard** | 12.7 | 0.8 |
| **Fine Paper** | 78.4 | 5.1 |
| **Glass** | 4.2 | 0.3 |
| **#1 Plastic** | 23.3 | 1.5 |
| **#2 Plastic** | 19.1 | 1.2 |
| **#5 Plastic** | 17.0 | 1.1 |
| **#6 Plastic** | 33.9 | 2.2 |
| **Hard Plastic** | 55.1 | 3.6 |
| **Newspaper** | 12.7 | 0.8 |
| **Food Waste** | 125.1 | 8.1 |
| **Cans** | 4.2 | 0.3 |
| **Scrap Metal** | 2.1 | 0.1 |
| **OR Wrap** | 27.6 | 1.8 |
| **Electronics** | 1.1 | 0.1 |
| **Confidential Documents** | 1.1 | 0.1 |
| **Examination Gloves** | 95.4 | 6.2 |
| **Diapers** | 390.1 | 25.2 |
| **Food Wrappers** | 19.1 | 1.2 |
| **Paper towels** | 201.4 | 13.0 |
| **Rubber** | 4.2 | 0.3 |
| **Soft Plastic** | 176.0 | 11.4 |
| **Blood-Containing Waste** | 12.7 | 0.8 |
| **Textiles** | 38.2 | 2.5 |
| **IV Bags and Tubing** | 108.1 | 7.0 |

| | | |
|---|---|---|
| **Wood** | 0.0 | 0.0 |
| **Styrofoam** | 14.8 | 1.0 |
| **Disposable Hospital Wear** | 46.6 | 3.0 |
| **Total** | **1548.7 kg** | **100%** |

The 2013 waste audit revealed that 28.5% of the hospital's landfilled waste stream was divertible. This represents a decrease of 22% in the amount of divertible waste inappropriately sent to landfill. This indicates that the waste reduction initiatives, implemented under the organization's HEMF, were successful in reducing landfilled waste and increasing recycling at the facility.

**APPENDIX C: Policies and Procedures for New Initiatives**

**1) GREEN TEAM TERMS OF REFERENCE**

## Green Team Terms of Reference

### Purpose

The hospital is committed to the promotion of a healthy environment by implementing effective environmental management practices. The organization will comply with all applicable legal requirements, and when possible, exceed such within our organization.

### Major Responsibilities

The hospital's Environmental Management System will continue to be developed, implemented and assessed.

The organization will apply sustainable development and pollution prevention principles and practices to the activities it undertakes and the services it provides. The organization will strive to reduce the consumption of resources, such as water and energy, by monitoring and regulating usage.

### Membership

Core membership shall consist of, but is not be limited to:

- Supervisor, Environmental Services
- Representative from Lab
- Representative from Physical Plant
- Representative from OR
- Representative from DI
- Representative from Administration
- Representative from Nursing

Ad hoc membership shall consist of, but is not limited to:

- Coordinator, Infection Prevention and Control
- Clinical Support
- Area Champions

**Accountability**

The Committee is accountable to the hospital's Executive Leadership Council.

**Quorum**

A quorum will have been reached when 50% or more of the members are present.

**Evaluation**

The Committee shall annually evaluate its effectiveness in meeting its major objectives and designated responsibilities.

**Frequency of Meetings**

Quarterly, or at the call of the Chair.

Approval Date November 14th, 2012

## 2) BLUE WRAP RECYCLING POLICY AND PROCEDURE

**POLICY:**

1. Blue wraps are composed of polypropylene (#5 plastic) and will never break down in landfill[1].

2. Staff must place all used blue wraps in their department's designated blue wrap recycling bins.

3. Blue wraps are not to be disposed of into the trash.

**PROCEDURE:**

**For frontline staff:**

1. When faced with disposing blue wrap, place the item in the designated blue wrap recycling bin (not in the trash, and not in the plastic or paper recycling bins).

**For Environmental Services staff:**

1. Line blue wrap collection bins with clear bags.

2. Empty the blue wrap collection bins as they become full (or after each case in the OR).

3. Place full bags with the other waste from your area for collection.

**For Environmental Services waste removal staff:**

1. Collect blue wrap bags, and place them into the cardboard compactor.

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[1] Arutchelvi, M., Arkatkar, A., Doble, M., Bhaduri, S., & Uppara, P. (2008). Biodegradation of Polyethylene and Polypropylene. *Indian Journal of Biotechnology* (7), 9-22.

**3) COMPOSTING POLICY AND PROCEDURE**

**POLICY:**

1. Composting food waste is better for the environment than sending it to landfill[1].

2. Food waste, wherever possible, is to be composted.

**PROCEDURE:**

**For Kitchen Staff:**

1. Collect all food preparation waste in a designated bin, to be emptied into the composter.

2. Segregate all food waste from returned patient meal trays, and place it into the composter.

3. Run the composter overnight (start the machine after the supper trays have been stripped, and the cycle will be finished before breakfast the next morning).

4. Remove the fertilizer end-product each morning, and place it in the designated holding area. A local non-profit organization will collect the fertilizer each Tuesday, Friday, and Sunday.

[1] Seng, B., & Kaneko, H. (2012). Benefit of Composting Application Over Landfill on Municipal Solid Waste Management in Phnom Penh, Cambodia. *WIT Transactions on Ecology and the Environment* (163), 61-72.

## 4) TRADITIONAL RECYCLING POLICY AND PROCEDURE

**POLICY:**

1. The hospital must pay to send waste to landfill, but recycling is free (the more waste we recycle and divert from landfill, the more money we save).

2. Staff must place all recyclable items in designated recycling bins to protect the environment[1].

3. Waste categories to recycle include:

- All paper products
- All metal products
- All glass products (except broken glass, which must be disposed of in a sharps container)
- All plastic products, regardless of the recycling number (except plastic films, such as plastic bags)

**PROCEDURE:**

**For all staff:**

1. Place all recyclable items in designated recycling bins.

2. Do not place recyclable items in the trash.

**For Environmental Services Staff:**

1. Line recycling bins with clear bags.

2. Empty recycling bins when they become full, and place recycling bag in designated collection area.

**For Environmental Services Waste Removal Staff:**

1. Collect recycling bags throughout the hospital and place them in the designated 96-gallon totes in the receiving area.

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[1] Gentil, E., Gallo, D., & Christensen, T. (2011). Environmental Evaluation of Municipal Waste Prevention. *Waste Management* (31), 2371-2379.

## 5) RESUABLE PHARMACEUTICAL WASTE CONTAINER POLICY AND PROCEDURE

### POLICY:

1. Pharmaceutical (medication) waste, if sent to landfill, can leach into the groundwater and harm those who use this water source (humans, animals, plants)[1].

2. Staff must put all pharmaceutical waste in the reusable pharmaceutical containers to ensure it is processed safely.

3. No other waste is to be placed in the pharmaceutical containers.

### PROCEDURE:

**For Nursing Staff:**

1. Place all unused medication, including non-empty vials, tablets, capsules, etc., into the reusable pharmaceutical containers.

2. Do not place any other items into these containers.

3. When containers are full, replace with an empty container, and place the full one in the soiled utility room.

**For Environmental Services Waste Collection Staff:**

1. Collect full pharmaceutical containers from soiled utility rooms.

2. Store in designated holding unit in the waste compactor area.

[1] Environment Canada (2005). Waste Management: Pharmaceuticals. Retrieved from http://www.on.ec.gc.ca/pollution/ecnpd/pharmaceuticals_e.html.

## 6) BIOMEDICAL WASTE CONTAINER POLICY AND PROCEDURE

**POLICY:**

1. Staff must put all biomedical waste into biomedical waste containers.

2. No other waste is to be placed in the biomedical waste containers. Biomedical waste is the most expensive waste stream to have removed. To save the hospital money, only biomedical waste can be placed into the biomedical waste containers.

3. Biomedical waste includes[1]:

- Anatomical waste
- Items saturated (dripping) with blood
- Items contaminated with blood that is known or suspected to be infectious (for known or suspected infectious cases, the item does not have to be saturated with blood)

4. Biomedical waste does not include:

- Items contaminated with non-infectious blood, but not saturated
- Recyclables (paper, plastic, metal, glass)
- Any other waste

**PROCEDURE:**

**For Nursing Staff:**

1. Place all biomedical waste into the reusable biomedical waste containers.

2. Do not place any non-biomedical waste into the containers.

3. When containers are full, replace with an empty container, and place the full one in the soiled utility room.

**For Environmental Services Waste Collection Staff:**

1. Collect full biomedical waste containers from soiled utility rooms.

2. Store in designated holding unit in the waste compactor area.

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[1]Ontario Ministry of the Environment (2009). Guideline C-4: The Management of Biomedical Waste in Ontario. Retrieved from http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/ resource/std01_079528.pdf.

## 7) AUTOMATED BEDPAN FLUSHER POLICY AND PROCEDURE

### POLICY:

1. Bedpans and urinals are classified as non-critical items, requiring low-level disinfection after each use[1].

2. Manually emptying and disinfecting bedpans and urinals leads to staff contamination through splashing of body fluids[2].

3. Manual disinfection is often insufficient, and can lead to patient infection[3].

4. Staff must use the automated bedpan flushers located in soiled utility room to empty and disinfect used bedpans and urinals after each use.

5. Emptying and cleaning of bedpans and urinals in any other manner is unacceptable.

### PROCEDURE (For Nursing Staff):

1) Wearing gloves, cover soiled bedpan with lid, and take it to the soiled utility room.

2) Wave gloved hand in front of Typhoon sensor to open door.

3) Place full bedpan in Typhoon.

4) Wave gloved hand in front of Typhoon sensor to close door.

5) Choose cycle length (1 for lightly soiled, 2 for moderately soiled, 3 for heavily soiled).

6) Remove gloves and perform hand hygiene.

7) Remove disinfected bedpan after cycle finishes and place in designated clean item storage.

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[1] Lobè, C., Boothroyd, L., & Lance, J-M. (2011). Bedpan processing methods: Making an informed choice. *The Canadian Journal of Infection Control* 26 (3), 165-171.
[2]Gerba, C., Wallis, C., & Melnick, J. Microbiological hazards of household toilets: Droplet production and the fate of residual organisms. *American Society for Microbiology* 30(2), 229-237.
[3] Hastings, M., Lami, R., LeClaire, R., & Noyes, G. (1998). Bedpan and urinal sterilization." *The American Journal of Nursing* 43, 1035-1036.

## 8) AQUEOUS OZONE CLEANING SOLUTION POLICY AND PROCEDURE

**POLICY:**

1. It has been proven that workplace exposure to chemicals and disinfectants can lead to skin irritation[1] and asthma[2].

2. Aqueous ozone (water with extra oxygen molecules) has been proven to be an effective sanitizer, capable of killing microbial pathogens[3].

3. Environmental Services staff must use aqueous ozone as the single cleaning agent for all public areas, as well as non-high-touch surfaces in patient rooms (windows, floors, etc.).

4. Eau3 Distributing Inc. (the aqueous ozone vendor) is in the process of having their product approved for use in all hospital areas in Canada. This has already been approved in the USA for use in patient rooms. As soon as it is approved in Canada, Environmental Services staff must use aqueous ozone as the sole cleaning agent for all surfaces throughout the organization.

**PROCEDURE:**

1. Aqueous ozone dispensers are located in the Environmental Services closets throughout the facility.

2. Dispense aqueous ozone directly into squirt bottle, bucket, autoscrubber, etc., at the start of each shift, and use in place of chemicals for cleaning all surfaces in public areas, as well as non-high-touch surfaces in patient rooms.

3. Upon shift completion, the aqueous ozone can be poured down any drain (sink, toilet, etc.).

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[1] Slotosch, C.M., Kampf, G., & Loffler, H. (2007). Effects of Disinfectants and Detergents on Skin Irritation. *Contact Dermititis* 57 (4), 235-241.
[2] Zock, J-P., Vizcaya, D., & Le Moual, N. (2010). Update on Asthma and Cleaners. *Current Opinion in Allergy and Clinical Immunology* 10 (2), 114-120.
[3] Zuma, F., Lin, J., & Jonnalagadda, S. B. (2009). Ozone-Initiated Disinfection Kinetics of Escherichia Coli in Water. *Journal of Environmental Science and Health – Part A: Toxic/Hazardous Substances and Environmental Engineering* 44 (1), 48-56.

**APPENDIX D: Annual Hospital Styrofoam Usage**

Cafeteria:

| Item | Number of Cases | Items per Case | Total Number of Items |
|---|---|---|---|
| 10 oz. cup | 38 | 1000 | 38,000 |
| Gravy dish | 114 | 1000 | 114,000 |
| 8 oz. cup | 70 | 1000 | 70,000 |
| Large soup bowl | 52 | 1000 | 52,000 |
| Small soup bowl | 54 | 1000 | 54,000 |
| Small plate | 56 | 1000 | 56,000 |
| Small clamshell | 38 | 560 | 21,280 |
| Large clamshell | 104 | 150 | 15,600 |
| | | | **420,880** |

Coffee Bar:

| Item | Number of Cases | Items per Case | Total Number of Items |
|---|---|---|---|
| 10 oz. cup | 72 | 1000 | 72,000 |
| 12 oz. cup | 48 | 1000 | 48,000 |
| 14 oz. cup | 48 | 1000 | 48,000 |
| | | | **168,000** |

Patient Water Pitchers and Cups (Nursing Units):

| Item | Number of Cases | Items per Case | Total Number of Items |
|---|---|---|---|
| 32 oz. pitcher | 5,894 | 25 | 147,350 |
| 6 oz. cup | 22,356 | 25 | 558,900 |
| | | | **706,250** |

# VITA AUCTORIS

| | |
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